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THE ROMANCE AND ENGINEERING OF FOOD PRESERVATION[1]

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THE ELEMENTAL FOOD CYCLE

NATURE has provided a cycle for the conservation of the plant foods of this earth from one generation to another. Man in creating certain processes of civilization has defeated some of the purposes of nature by diverting constituent parts of the plants and animals from this cycle to uses for commercialized civilization.

In this diversion process these essential elements have been directed into modern sewage systems comprised of drainage streams and canals, and hence they have been deposited far from their points of origin. This diversion of the elements from the lands of their origin has slowly impoverished in strategic populated regions the animal-plant cycle established by nature. It has reduced the effective value of the essential elements where life has elected to live, and this to a critical degree especially in some regions.

It is very significant and fortunate that many of the elements to create food for living organisms are inexhaustible. As an example, carbon, oxygen, nitrogen and hydrogen are found in limitless and bountiful quantities in the air and water. From these elements starch, sugar, fats, fibers and protein are all produced. In other words, these several foods are made from unlimited constituents of air and water, transformed under the influence of the sun by the several botanical and biological processes into edible products. Chemically, each of these products originates from an inexhaustible source of supply.

On the other hand, many of the essential plant food elements that are contained in the soil are exhaustible. Potash, phosphate, calcium, magnesium, sulphur, iron,

[1] Address of the retiring vice-president and chairman of Section M (Engineering), prepared for the New York meeting of the American Association for the Advancement of Science.

copper and manganese when joined with some of the inexhaustible elements from the air and from water give us the most common organic compounds that occur in various forms in vegetables, in flesh and in bone structure. These organic compounds might be found in the form of wheat, cottonseed, corn, carrots, potatoes, bacon, mutton, beets, soybeans, etc., yet only a very small part of even these compounds are exhaustible. One hundred pounds of corn, for instance, contains only about one and one-half pounds, while a whole ton of tomatoes contains not over ten pounds of exhaustible elements. Table 1 shows the exhaustible element relationship of these and other food products.

TABLE 1

TABLE SHOWING EXHAUSTIBLE ELEMENTS NECESSARY TO PRODUCE ONE HUNDRED POUNDS OF FOOD PRODUCT

Name of product	Exhaustible elements expressed in pounds necessary to produce one hundred pounds of edible product
Apples	.5
Bananas	1.
Bacon	5.
Beef steak	1.5
Butter	4.
Chicken	1.5
Corn	1.5
Cottonseed	5.5
Milk	1.
Oats	5.
Oranges	1.
Peaches	1.
Potatoes	1.
Raspberries	1.
Soybeans	7.
Tomatoes	.5
Wheat	2.5

H. A. Morgan, formerly president of the University of Tennessee, and later chairman of the Board of the Tennessee Valley Authority, points out that since nature did not anticipate and provide for the use of her mineral elements and their resultant plant and animal compounds by man except as they should remain in the animal-plant cycle, eventually man must look forward to restoring the continuity of nature's program or he must follow the elements discharged into the rivers and take up his abode in the deltas and the flood lands. This procedure is not visionary, as is evidenced by some civilizations that have already had to adopt this method of feeding their multitudes.

In Fig. 1 is shown diagrammatically the interdependence of animal and plant life in the program of nature. Plant life is devoured or consumed by the animals, but all the constituent exhaustible elements are returned to the land either as fertilizers or as bone elements. Upon these plant foods new plant life subsists and furnishes the food for further generations of animal life. Our phosphate beds of today are the burial grounds of animal life of the eons of yesterday.

Fig. 2 indicates how man has upset the continuity of this plan by diversion of essential elements through the transportation and sewage systems of present-day civilization. Examples are multiple of man's upset of this natural sequence of fertility restoration.

For the most part each plant and each animal uses the same elements for its existence. Sixteen ele-

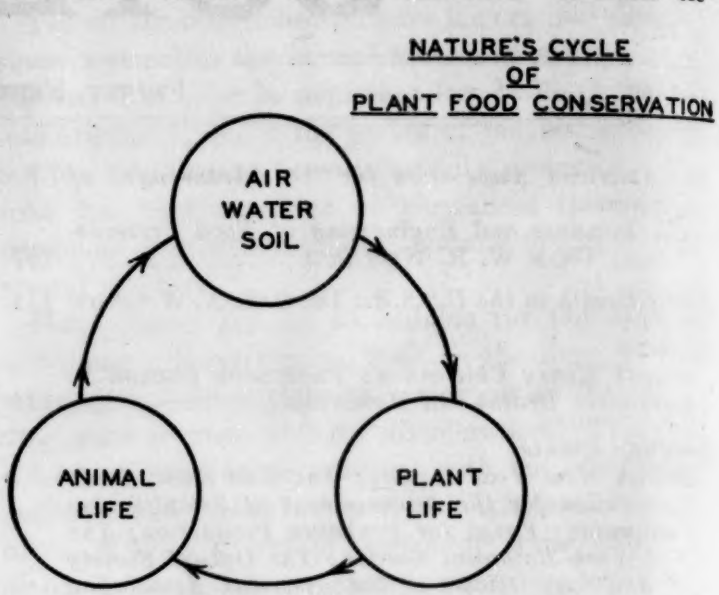

FIG. 1.

ments of the known ninety-two furnish almost the entire needs of the animal and plant life of the world. These are shown in their relation to each other in Tables 2 and 3. Of these sixteen, the three most

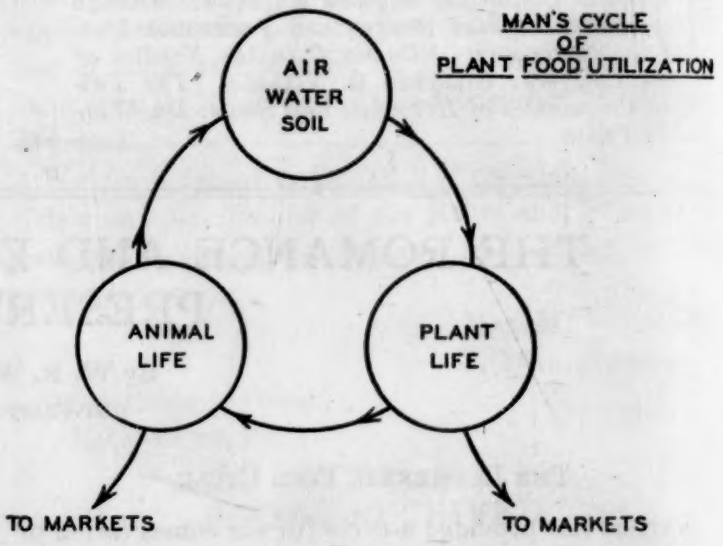

FIG. 2.

important and critical food elements are nitrogen, potassium and phosphate.

Of nitrogen there is a supply of twenty million tons over each square mile of the surface of the earth.

Of potash there is a fairly uniform supply distributed in the crust of the earth on all continents. There is no present evidence that we shall ever have a world shortage.

There are, however, real limitations of the third element, phosphate. Fortunately, nature has played a very important role in preserving for man that phosphate which he now has available. As it occurs in its natural formation most phosphate is locked up for the present and future generations through the implement

of a small key of fluorine. This key modern engineering has been able to turn and thus unlock for our needs by high temperature electric or blast furnaces the phosphate products necessary to replace those that have been dissipated into sanitary sewage channels and transported to distant points of commerce.

Since the exhaustible elements of the earth are those of the soil there exists the idea that the fortunes of

TABLE 2

INEXHAUSTIBLE ELEMENTS FURNISHED TO THE ANIMAL-PLANT CYCLE BY AIR AND WATER AND THE EXHAUSTIBLE ELEMENTS FURNISHED BY THE SOIL

Air and water furnish the inexhaustible elements	Soil furnishes the exhaustible elements
Carbon	Phosphate
Oxygen	Calcium
Hydrogen	Potash
Nitrogen	Magnesium
	Sulphur
	Iron
	Zinc
	Boron
	Iodine
	Cobalt
	Copper
	Manganese

civilization depend in the ultimate upon the ability of the occupants of this globe to preserve the soil. This is quite true, but the breakdown can be carried to a more elemental analysis. Primarily, the ultimate fortunes of humanity depend upon the ability of the peoples on the face of the earth to conserve by careful utilization the phosphate portion of the soil for the generations yet to come.

TABLE 3

FOOD COMPOUNDS PRODUCED FROM INEXHAUSTIBLE SOURCES AND THOSE PROVIDED FROM THE SOIL

Air and water furnish for plants from inexhaustible elements	Air and water furnish for animals from inexhaustible elements	Soil furnishes from exhaustible elements
Starch	Fats	Organic Compounds
Sugar	Energy	Bone
Fats	Protein	Nature did not provide for man's diversion of these compounds from the animal-plant life cycle
Fibers and textiles	Heat	

More progress has been made in the research and development of phosphate extraction and processing for plant food during the past decade than had occurred before in any one hundred years. The world is beginning to recognize its dependence upon this essential element of human existence. Modern engineering is now providing the procedures and processes to conserve and utilize even the low quality and the isolated beds of the world supply of this strategic element.

FOOD HABITS OF MAN AND HIS NUTRITIONAL DEMANDS

Up to the present era, man has not been as greatly interested in the elemental food cycle and the conservation of our essential food elements as he has been in getting enough to eat each day and in being reasonably sure that he has a sufficient supply for himself and his family for his annual needs.

There is no historical evidence to indicate when man learned his lessons from the instinctive habits of the lower animals that inspire them to store food for the winter months. There is ample evidence that from the dawn of history his eating habits have been very profoundly affected by his ability to conserve the available edible foods over periods of scarcity.

Both in the lower animals and in man the nutritional requirements have been largely determined by instinct. Since the nutritional needs of a man do not change appreciably from one generation to the next, the process of trial and error that has extended over hundreds of years has created a large number of "do's" and "do nots" about traditionally accepted foods.

Since each plant and animal does use approximately the same chemical elements of nature in its growth, but these same plants and animals do vary considerably in quantity of any one element, those people who have been able to utilize a diversified number of plants and meats for their diet have not suffered seriously from any particular deficiency of nutritive food. Food habits, however, have had to adjust themselves to the availability of foods, and in most climates this has been very greatly affected by the facilities to preserve the foods during seasonal or famine periods.

Many of our older nations and civilizations, especially those in hot climates with frequent crop failures, developed food habits primarily centered about cereal and grain foods. These foods could be preserved by the known experiences of the clan or nation over long periods of time. The granary plan of Joseph, repeated in many of its variations in Europe and the Orient, brought about national diets composed mostly of starchy foods. Our physiologists tell us that the granary plan of Joseph left its mark on the residents of Egypt if the tooth diseases of those remains found in the crypts of Egypt is any fair basis of judgment.

For the most part the peoples of a very warm climate also are very partial to sauces and seasoning of a very high and distinctive flavor. Much of this can be traced back to the desire to counteract the taste of partially decayed meat and fish foods through the hot sauces spread thereon.

Even within continental United States in its relatively short history of two centuries the food habits have been very definitely affected by the ability of the people to store and preserve food. Within the north-

ern areas, wheat bread, cellar-stored vegetables and snow- and ice-preserved beef and mutton were used in the winter, but the meat portion of this diet was changed in the summer to pork and chicken when the available preservation facilities for beef and mutton were not workable. On the other hand, within the southeastern states, pork and corn breads were generally accepted as an all-year-around diet. With the lack of snow and ice for preserving the beef and mutton products of the South, pork became the all-year-around meat for the southern table with a liberal introduction of chicken, which could be maintained alive until needed but was small enough to be consumed within a few hours after killing. These examples might be multiplied. A sampling of the tables of the United States prior to 1900 would have revealed that nearly every area was most provincial in its food habits. Since 1900, however, several forces have been at work making possible an effective change in these habits.

Prior to 1900 the nation lacked mobility. It was dependent upon an artery system of railroads to move goods of all kinds. Furthermore, its power systems were highly localized.

Almost simultaneously, three engineering developments changed the features of American life. Out of these three developments, historic changes were destined to bring about decentralization of American industry, new power facilities to American homes and a greater advance in the mobility of man within a quarter of a century than had been experienced from the dawn of history to the year nineteen hundred A.D. These three developments were (1) an interconnected electrical distribution system for all America; (2) mass production of the automobile and the truck, and (3) construction of a network of highways that went to virtually every farm and urban door of the nation.

The interconnected system of electrical distribution made available to most American homes facilities for processing and preserving perishables for use at any period of the year, and through the availability of the trucks and highways thousands of truck loads of fresh vegetables, dairy products, fruits and meats moved daily from one region to another. Florida, Texas and California fruits and vegetables left their semi-tropical gardens daily in winter to the ice-bound centers of the north, even into northern Canada. In the summer the same northern areas would move large tonnages of their perishables to the south.

While food preservation had been carried on within the United States for its entire history, the turn of the century marks the upward swing of many of the most essential processes for the most effective preservation of the grown perishables of the nation.

There is in each area a very definite relationship between family income and class of food consumed. In general each individual in the United States consumes one ton of food each year. If the income is high the purchases will include the more expensive available foodstuffs and *vice versa*. But in the past the locally produced foods that could be readily preserved constituted the principal poundage of human consumption because they were the cheapest. But few have suffered from lack of weight of food even during depressions, though many have found it necessary to make up their meals from low-priced starches and fats when incomes were depressed.

The Engineering of Food Preservation

For the most part there are four methods of food spoilage or deterioration: (1) odor absorption, (2) enzyme action, (3) bacterial growth and (4) oxidation.

While for the commercial market other factors such as color change, lack of freshness and shrinkage may be given great market consideration, these are closely related to the more serious deterioration factors outlined as above.

Odor absorption has been recognized for centuries in the storage of foods. It has been most serious in the storage of dairy products such as butter, cream and ice cream. In general, the transfer of odors is a function of the temperature of storage. Butters maintained at a very low temperature are much more free of the absorption of odors than when stored warm. Probably this is brought about by two actions. When the affected product is completely frozen or crystalline, then its absorptive capacity is greatly reduced. But also, when the offending odor source is at a low temperature, the volatile odors are at a minimum. When the temperatures of both the absorbing food and the offending source of odor are high, both the absorption capacity and the odor action are intensified.

Enzyme action has been one of the most difficult of the deterioration processes to inhibit. It remains, still, as the process of which we know the least, due to the great complexity and the multiple catalytic activities of the several enzymes.

Some one has referred to enzymes as the unorganized system of ferments in contra-distinction to an organized ferment such as yeast. Another food technologist defines the enzyme as "the catalyst of living cells." Probably a more exact definition is that "an enzyme is a heat-labile catalyst elaborated by living cells yet capable of acting independently of the living processes of the cell."

Bacterial growth has been recognized as of great importance for several generations. Its prominence is evidenced by the acceptance of the study of bac-

teriology as a major science in courses related to health, medical service, sanitation, food preservation and water supply. Unfortunately, the public has been given sufficient misinformation about bacteria so that today to many people all bacteria are harmful. A large portion of the buying public does not realize that many of the food-preserving processes must depend upon certain bacteria for their successful operation, while other bacteria cause deterioration and decay.

Oxidation is generally most active under high temperature conditions. Often the oxidation is associated with one of the other three deterioration actions.

Processes Used to Prevent Deteriorating Actions in Foods

The principal processes of food preservation are (1) drying or dehydration; (2) sterilization and canning; (3) low temperature chilling and freezing, and (4) chemical preservation including pickling, smoking, spicing and fermentation, etc.

Each of these types of food preservation has certain time limitations with the exception of freezing. The recorded discovery reported by the Smithsonian Institution[2] in recent years of mammoth flesh and other animal carcasses many thousands of years of age yet still in edible condition is mute evidence of the permanence of food preservation by sharp freezing.

Dehydration, canning and quick freezing are each of great moment at the present and will be discussed further.

Preservation by Dehydration

Dried foods have been prepared for thousands of years. Either the sun or some artificial source of heat was used to evaporate the excess water. In most of these processes the water was seldom carried lower than 12 to 25 per cent. In no case is there evidence that great care was exercised to maintain controlled treatment of the product in the drying process as between humidity, enzyme action, air velocity and temperature.

Wars have most generally increased interest in the drying of foods, and in recent years dehydration has become an important part of the food programs of armies. Unfortunately, most of the demand for dehydrated foods recedes after each war period, and this recession causes the liquidation of both plants and trained personnel. Probably as a part of the permanent preparedness program of the nation the perishable food supplies areas should maintain, under the Army or Navy direction, base plants for food dehydration, these plants to operate primarily as stand-by units for war emergencies. The nation would then find it could maintain its gains in the science of food evaporation from one period of war emergency to the next.

Much argument can be exercised trying to differentiate between dried foods and dehydrated foods. In the language of the public, no line of demarcation exists between the drying and the dehydration processes. There has been an attempt on the part of food technologists to define the field of activity of food driers as that in which foods are produced down to 10 or 25 per cent. moisture without specific control of the relation of enzyme action, temperature and humidity, while dehydration is defined as a process in which scientific control is maintained as between temperature, humidity, air velocity and enzyme action to evaporate foods to moisture contents of 2 to 8 per cent.

The writer would define dehydration as "the removal of water from food products to required low values of moisture content by a process of controlled temperature, humidity, air velocity and enzyme action, and the resultant product to permit rehydration with a minimum loss of original natural color, flavor, odor and nutritive value."

There are many reasons for dehydrating products for war purposes. Principal advantages of dehydrated foods are:

(1) There is a reduction to a small fraction of the original weight.
(2) The processed product can be compressed into a small cargo package without destroying its rehydration qualities.
(3) The requirements for metal containers are reduced.
(4) They can be subjected to freezing temperatures or hot climates with considerable success.
(5) The process can be operated with a minimum of critical materials.

The principal disadvantages of dehydrated foods are the change of flavor with age, the susceptibility to vermin and the ultimate perishableness of the food.

While dehydration can be carried on by cabinet, drum, spray, rotary cylinder and tunnel driers, fully 80 per cent. of the present supply comes from tunnel equipment.

At the end of World War I, the United States had about twenty dehydration plants in operation, but most of these fell into disuse before 1938. At present this country has over one hundred plants making upward of 100,000,000 pounds of dehydrated products annually. By 1944 this capacity should be quadrupled.

It is reported that Germany's curve of dehydrated plant construction would show three plants in 1900, eight hundred in 1915, eighteen hundred by the close of World War I. It is well known that hydrated and

[2] Annual Report of the Board of Regents of the Smithsonian Institution (1902–1903), p. 621.

ersatz foods are very prominent articles of sustenance in Germany today and probably exceed its 1918 peak several fold.

The 1943 requirements of dehydrated foods in the United States exceed 400,000,000 pounds. Over a billion and a quarter pounds of dehydrated foods have been used in the present war by the Allied nations.

To give some physical impression of what dehydration means to the transportation systems under the present practice, eight carloads of fresh potatoes become one carload of dehydrated product and ten ships for fresh meats can be replaced by one ship for the dehydrated equivalent.

So great has been the contribution made by dehydrated products in this world conflict that never again should the democratic peoples permit their gains in accomplishment in the science of dehydration to revert to a position of subordinated emphasis. And further —if the United States has a vigilant interest in future preparedness, then sufficient productive capacity and yield should be maintained in dehydration plants as a national policy.

Preservation by Sterilization and Canning

While the preservation of food by canning dates back to the early work of Nicholas Appert in France in 1795 which brought him his first public recognition in the national competition of 1807, it did not take on the characteristics of an extensive industrial process until after the introduction of bacteriological control successfully used by H. L. Russell in 1895 for the pea canners of Wisconsin and expanded by S. C. Prescott and W. L. Underwood in 1896 in their epoch-making treatise on "Micro-organisms and Sterilizing Processes in the Canning Industries."

With these notable achievements in the control of food spoilage by the canning process, industry immediately responded, and in the early years of the twentieth century canning plants and can manufacturing flourished in both Europe and America. By the advent of the United States in the present war the canning industry within the nation represented a product output approximating a billion dollars annually with over three thousand producing companies.

While considerable improvements have been made in the laboratory control both from the bacteriological and chemical standpoint during the past forty years, the greatest impetus to the industry has been the development of new machinery to produce the cans, new mechanical engineering developments in cleaning, separating, sterilizing and packing the more than three hundred basic products now coming from the commercial canneries. Coincident with these mechanical developments have come new successes by the chemical engineers in the types of can surfaces and linings produced for the different foods to be preserved.

The excellent results now obtainable by process canning, the low cost of preserving by the canning method and the adaptability of the canning process for preserving the surplus foods in almost every region of the civilized world augur well for its future. There is every evidence that sterilized, hermetically sealed products will continue to be a very essential type of food in our daily life in America and Europe. Economically the preservation of food by canning is sound and the product produced is highly satisfactory.

Preservation by Quick Freezing

Since quick freezing is just emerging into a process that can provide foodstuffs at a price within financial reach of the majority of the people of the United States, it offers new opportunities for industrial expansion. As a new industry, quick freezing presents new problems to be met by the engineer.

Larger amounts of foods can be expected to be preserved by the freezing processes in the generations of the future. The increased facilities of transportation and the widening uses of refrigeration will make possible the preservation of foods by cold for the masses of American people. The fact that freezing is the one process that can provide preservation for an indefinite length of time and that by the new freezing processes the original flavors and colors can be retained, makes it the conservation method that will be most acceptable to the human race. The present state of the art of quick and flash freezing is now advanced to such a stage of perfection that with the release of equipment priorities after the present war, frozen foods can be made available to the purchaser at prices as low as those for hot processed and dehydrated products.

The term "quick-frozen" as applied to food is very elastic and much abused. Many cases are on record of products which have been frozen by methods that required as much as a week for complete solidification, yet they were labeled "quick-frozen." Such loose usage does not induce increased public confidence and acceptance. Too often the practice represents an attempt by some food processor to offer his cold-pack product under a classification that has the highest customer appeal in the food market. A previously proposed definition by the writer states: "Quick freezing is freezing at a rate sufficiently fast that there is no appreciable change in the physical or chemical properties of the product during the entire cycle of freezing and subsequent thawing."

More or less modification of any food may occur when it is frozen. Usually these changes are not apparent until the product has been thawed and in many cases further undesirable changes, due largely to enzyme action, may occur after defrosting is completed.

THEORIES ON CAUSE OF FOOD DAMAGE BY SLOW FREEZING

Several theories have been advanced to account for the effect of slow freezing. These include the cell-puncture theory, the bursting of the food cells by internal-osmotic-pressure theory, and the theory of the irreversible precipitation of colloidal constituents. Each of these will be discussed in order.

Cell-Puncture Theory. Perhaps the most widespread and persistent hypothesis is the cell-rupture theory, which holds that the cell walls are punctured by growing ice crystals, and that, upon thawing, the cell contents leak out through these minute ruptures. It is also held that, if the size of the ice crystals can be maintained less than the cell dimensions by rapid chilling, no puncturing with its consequent leakage will occur.

It should be borne in mind that foods are not composed of rigid inelastic cells. The walls are resilient and will permit considerable expansion before rupture occurs. Heat is removed from only one side of the cell so that expansion may occur on the opposite unfrozen side.

Microscopic observations have revealed that, even when freezing is exceedingly fast, the smallest ice crystals are much larger than individual cells. Many cells are contained in one crystal instead of *vice versa*. The crystal lattice both inside the cell and in the intercellular spaces is continuous. No tearing or shearing of cell walls has been observed.

Osmotic-Damage Theory. Petersen proposed that damage to foods during freezing is due to the following mechanism: "What crystallizes first in each cell is the pure water. That leaves the remainder of the juice in the cell more concentrated. The resultant increase in osmotic pressure tends to draw the water from the next adjoining unfrozen cell. The water coming into the partly unfrozen cell has a tendency to build onto the crystals between the cells when the rate of freezing is so slow that the system approaches equilibrium." It also accounts for the occurrence of collapsed cells contiguous to large ice masses in slowly frozen foods. However, this theory does not explain the damage which occurs in quick freezing when heat transfer so greatly exceeds diffusional rates at low temperatures that thermal equilibrium is attained before appreciable osmosis can occur.

Irreversible-Colloidal-Change Theory. Almost without exception perishable foods are colloidal systems in which the external or dispersing phase is an aqueous solution. This has led some investigators to the belief that alteration of the colloidal structure is responsible for changes during freezing, storage and thawing. While there are many factors which affect the stability of colloids, it is probable that only three concern the food processor.

(1) The lowering of temperature (distinct from the freezing effect) renders many colloidal dispersions unstable. Examples are the formation of gels from agar, soap and starch hydrosols. This phenomenon is often followed by syneresis, that is, shrinking of the gel and exudation of fluid.

(2) Chemical changes which occur during frozen storage are irreversible. Many of them are due to enzyme action. The rapid deterioration of frozen unblanched vegetables is well known. The "rusting" of oily fish (oxidation of the fat) is very familiar. It is probable that some of the loss of flavor from stored frozen foods may be traced to hydrolysis of esters and oxidation of unsaturated odorous components.

(3) Freezing causes concentration by removing liquid water from the external phase. More concentration, by decreasing the distance between dispersed particles, may bring about critical instability.

Freezing may also effect sufficient concentration of electrolytes to cause "salting out" of hydrophilic colloids. While such precipitation is often reversible, long storage in this state may result in an irreversible precipitate.

AN APPRAISAL OF THE THEORIES OF FREEZING DAMAGE

The freezing-damage theories might be appraised as follows:

Mechanical damage to cellular structures might be caused by ice crystals, especially for some classes of product. When this occurs, there is an internal shredding of the product, caused by growing crystals. The resultant damage is a function of the crystal size and freezing time.

Osmotic injury to cellular structure is possible but probably plays a minor role in the destruction caused by freezing. Water diffuses from unfrozen cells to the faces of growing ice crystals at a very slow rate. The action is irreversible when thawing occurs and might cause internal rupture.

Irreversible changes in the colloid system appear to be the principal cause for slow-freezing damage. Primary or secondary effects of low temperature cause irreversible precipitation of many colloids. This action is independent of cellular structure and explains the effect of freezing upon foods which do not consist of cells. The theory also accounts for the severe damage to some foods and the negligible damage to others when identical freezing technique is employed.

RAPID FREEZING RATES NOT ESSENTIAL TO ALL FOODSTUFFS

Many have a mistaken idea that very rapid freezing is equally desirable for all perishable foods that require preservation by cold. The need of rapid freez-

ing is much more pronounced for some perishables than for others. Furthermore, the colloidal composition of some products is such that even slow freezing affects the structure but slightly.

With most foods that are to be cooked as soon as defrosted, slow freezing is as satisfactory as quick freezing. In the case of meats, slow freezing may even have a tenderizing effect. Furthermore, any leakage of the meat subsequent to defrosting merely results in increased pan juices.

Vegetables with a high starch content display a much different response to the freezing treatment from leafy types that may exceed 90 per cent. of water by actual weight. Well-ripened berries and fruits with a high sugar content present a very different problem from acid and near-ripe fruit products.

Controlled supercooling and favorable colloidal action are utilized in the polyphase freezing process developed by Mr. Luis Bartlett and the author to flash-freeze foodstuffs. Unusually fast heat transfer is secured by direct contact of food with a chilled medium of high viscosity which is composed of three phases: Solid, liquid and vapor, hence the term "polyphase." A typical medium is composed of dextrose, sucrose and water. It is chilled and slowly agitated until a solid phase of finely divided ice particles has formed and is dispersed throughout the liquid. This composition is satisfactorily operated over the range −2F to −10F and is metastable at these temperatures.

Articles of food are floated in the cold medium and the slow agitation moves the articles with respect to the fluid and also to each other so the individual pieces are prevented from freezing together. Freezing is so fast that washwater or juices adhering to the food surfaces are at once frozen in place and do not dilute the polyphase medium. This film of ice is proof that diffusion of soluble constituents does not occur, solute is not transferred from the freezing medium to the food, nor does the food lose dissolved solids.

The high rate of heat transfer is due to three factors: (1) The extremely high thermal capacity of the polyphase state. (2) Increase in the thermal conductivity of the fluid film by the suspended ice particles. (3) Almost complete elimination of food supercooling by the "seeding" effect.

The polyphase medium removes heat approximately twice as fast as a liquid medium under identical operating conditions. Polyphase media, composed of water and sugars, may be operated in the metastable state at temperatures as low as −10F, while syrups employed in food freezing are seldom operated below +3F. Thus it is possible by employing the polyphase media to chill foods in a fraction of the time required by liquid media under ordinary operating conditions.

An important advantage of heat-transfer fluids which can be operated at subzero temperatures is that freezing is completed in one operation and no heat is removed in the storage room. By eliminating this period of exceedingly slow cooling, less irreversible damage to the colloidal structure occurs. Furthermore a more immediately practical result is that the food does not freeze into a solid mass in the container. Each piece retains its individual character so that it may be removed without disturbing the remainder and repackaging in smaller packages is easily accomplished.

Summation: The engineering profession of the world can be expected to give more attention to the animal-plant food cycles in the years ahead and to determine new methods of preserving for complete utilization the critical and exhaustible supplies of plant foods for the generations yet to live. Coincidentally with this obligation which the engineer must assume, there is the romantic but very real task ahead of applying the same intensive interest in the ultimate preservation of foods as the agriculturists have displayed in producing them.

The food preservation arts and sciences have now progressed forward far enough that the engineering profession can well assure the world that diets can henceforth be determined on the basis of what is good for man. With the coordination of our implements of electrical power, internal-combustion engine propelled transportation, excellent network of roadways and mechanical inventions, and with the competent support of the food technologists, the bacteriologists and the chemists, the engineering profession should be able to assure the multitudes that the world's ability to preserve is now prepared to equal the world's capacity to produce food. When complete coordination is effected, and production, preservation and distribution become daily realities, then the profession will have reached new heights in engineering, achievement, statesmanship and service.

PUBLIC HEALTH IN THE U.S.S.R.[1]

By Dr. C.-E. A. WINSLOW

YALE UNIVERSITY

DURING a period of rapid demolition and rebuilding of Yale University a student was showing his father about the campus and the father said, "What is that building?"

[1] Address at the Science Panel of the Congress Celebrating the Tenth Anniversary of American-Soviet Relations, New York, November 9, 1943. The complete proceedings of the Science Congress including the Medical Session will be published at a later date by the National Council of American-Soviet Friendship.

"Which building?" asked the boy.

"Oh," said his father, "you didn't look quick enough. It's gone."

Russia, since the October Revolution, has been like that; and I can, unfortunately, bring you no up-to-date picture of its kaleidoscopic changes. My last visit to the Soviet Union was in the summer of 1936 as a member of a mission of health experts from the Health Organization of the League of Nations, which was invited to study the health program of the Union and which traveled from Leningrad to Batum, from Kiev to Gorki, with that purpose in mind. During the past seven years, the opportunities for intimate scientific contact have been limited, so that I can only report on one passing phase of a panorama of progress. My picture of 1936 has, however, the advantage of earlier knowledge, since I spent the summer of 1917 in Russia as a member of a Red Cross Mission and left Leningrad on the night that the sailors moved in from Kronstadt to inaugurate the October revolution, whose anniversary is celebrated to-day.

To take one concrete illustration. In 1917, the sewage of the city of Moscow was disposed of by irrigation on vast sewage farms, one of the most ancient methods of sewage treatment, and one which—to the best of my knowledge—is still in use at Paris and Berlin. In 1936, this procedure had been replaced by an activated sludge process—one of the most modern and scientific in the world.

By 1935, the death rate from diphtheria in the larger Russian cities had been reduced to one fifth of what it was in 1913; and the incidence of syphilis, as measured by a greatly improved machinery for reporting, had declined to a similar extent. The infant mortality rate and the total death rate from all causes had fallen to about one half of the figure for 1913.

During the three years ending in 1935, 170 million vaccinations for smallpox had been reported for the Soviet Union. Typhus and cholera, which had spread disastrously during the terrible phase of civil wars, had been brought under control. We saw a well-equipped Anti-Plague Institute at Rostov, where comprehensive plans were being made for combating the wild rodent carriers of plague which threaten the Volga region and the Caucasus as they threaten our own West Coast states. At Novorrossisk, we visited an excellent quarantine station for protection against the importation of disease. Malaria and dysentery remained a major menace—as they remain to-day over a major portion of the earth's surface; but substantial progress had been made—particularly in Georgia and the Crimea—in control of malaria through anti-mosquito measures and local centers for treatment with atabrine.

The most outstanding feature of the whole public health program was perhaps its provision for the care of maternity and infancy. The Soviet Union was keenly interested in its mothers and children. Research and general planning was carried out by the Clara Zetkin Central Institute for Maternity and Infancy at Leningrad where the latest advances were being studied in control of communicable diseases (the use of BCG vaccine, for example) in nutrition; in child psychology and kindergarten technique. Well-equipped hospitals and infant welfare stations had been established in the cities, and smaller centers were being developed throughout the rural areas, so far as limitations of personnel and equipment would permit. To facilitate the rapid increase in industrial employment of women, welfare stations and day nurseries had been established in the factories, in the Parks of Culture and Rest and in the railroad stations on a scale which we should do well to emulate in this country in the present war emergency. All in all, I am inclined to think that the Maternity and Infancy Program of the Soviet Union in 1936 was the most intelligent and far-reaching program of its kind in the world.

A second major emphasis of the Union health campaign was on the health of the industrial worker. Here, the center of research was an Institute of Industrial Diseases in Moscow with hospital and outpatient services of its own and where scientific investigations of the first order were carried out on mercury and other occupational hazards. In the factories, themselves, as, for instance, in the Molotov automobile factory at Gorki, we saw excellent hospitals and polyclinics and day nurseries for the workers —an exceptional model plant, to be sure, but one which would be hard to match in the model plants of other lands. Of particular interest was the provision of rest houses and sanatoria where the worker could spend his holidays or where the tuberculosis case or convalescent could be sent for longer periods. Nearly all the luxurious villas of the ancient aristocracy—in the Crimea, for example—were in use for this purpose; and many larger new institutions had been built, such as the magnificent sanitarium for the Red Army at Sochi. Some of these institutions were for children; and one of my most unforgettable memories of the summer of 1936 is the Young Pioneer Camp on the Crimea near Yalta, a vacation camp for children from all over the Union who had distinguished themselves by some distinguished service to the state. After a brief ceremony on the playing field (in the nature of a Boy Scouts' Parade) the formation broke up and the boys rushed up to our seats to make friends. With one of them firmly attached to each hand, we went up the hill to supper; and I discovered

that one of my new-found friends' good deed had been the prevention of a train wreck by giving warning of an accident to the line.

The scope of the health program of the Soviet Union is, of course, a broad one, since it recognizes no artificial boundary between prevention and cure and provides medical care to all the people as a right of citizenship—just as we provide education in the United States. As rapidly as circumstances would permit, hospitals, polyclinics (industrial and regional) and the services of regional physicians and nurses had been provided, organized to provide routine preventive service, prophylaxis and medical care. Medical education—as in all continental European countries—was conducted by the state but with the interesting provision—without cost—of refresher courses for physicians every three years. Vigorous efforts were being made to increase the meager supply of hospitals and physicians available during the pre-revolutionary period. In Georgia, for example, the hospital beds had been multiplied fourfold and the number of physicians, tenfold, since 1913. Five hundred and seventy-seven primary medical centers had been established in the rural areas of that province alone.

The Soviet Union fully recognized the importance of scientific research, as the basis for progress in medicine and public health. I have mentioned several of the lavishly equipped institutions which guide progress in the fields of maternity and infancy and in industrial hygiene. I can not omit reference to the Central Institute for Nutrition in Moscow with its three divisions for physiology of nutrition, food sanitation and food technology; the institute directed by Dr. Lena Stern at Moscow; and that mecca for physiologists, the Pavlov Institute outside of Leningrad. A monograph by A. D. Speransky on "A Basis for the Theory of Medicine," published shortly before our visit, is one of the most challenging approaches to the basic physiological problems of disease which has appeared in any country in the present century.

Seven years in the history of Soviet Russia is a long time as measured by the slow-motion progress of less dynamic lands. The one thing which the Commissar for Public Health emphasized to us was "We are never satisfied." What new progress was made between 1936 and 1941 we do not know. How the terrific sufferings of the past two years have set back that progress, we do not know. But of some things we may be sure. The Soviet Union is dedicated to the physical and emotional and social health of its people, with an unusually vivid consciousness of that aim. It has advanced on the road to that ideal at an almost unparalleled rate. It will go forward on the road after the war is won and the threat of Nazidom lifted from the world. We want to share with the health leaders of the Soviet Union in their glorious tasks. We want to help them—if in any way we can. We want to learn from them as they go forward in their future advance. We are comrades together, not only in the war for the four freedoms but in the longer even more fundamental war for the health and welfare of the human race.

OBITUARY

RUSSELL HENRY CHITTENDEN

WITH the passing of Russell Henry Chittenden on December 26, 1943, an era in physiological chemistry in the United States may be said to have come to a close. "The first definitive laboratory of physiological chemistry in America for the instruction of students was established in the Sheffield Scientific School at Yale University in 1874";[1] the direction of it was placed in the hands of Chittenden, a young man eighteen years of age, who at that time was a candidate for the bachelor of science degree in the Sheffield Scientific School. This young man was born in New Haven, Conn., on February 18, 1856, the son of Horace Horatio and Emily Eliza Doane Chittenden; his family traced back to William Chittenden, who came to this country from the parish of Cranbrook, Kent, England, in 1639. The young man was educated in the public schools of New Haven and prepared for Yale in the French Private School there. At first he intended to study the classics, but a growing interest in natural science turned him toward the study of medicine and therefore matriculation with the Sheffield Scientific School. At the age of nineteen Russell Chittenden received his B.S. degree, having offered a thesis entitled "Glycogen and Glycocoll in the Muscular Tissue of Pecten irradians," which was published in the *American Journal of Science and Arts*. Its translation into German and subsequent publication in Liebig's *Annalen der Chemie* was destined to be the open sesame for the young man's acceptance as a student in 1878 in Kühne's laboratory at the University of Heidelberg. The young man had made his plans to enter Hoppe-Seyler's Institute of Physiological Chemistry at Strassburg but was disappointed by what he saw when he arrived; neither the city nor the laboratory made a favorable impression on him. To use his own words, "Intuition is not to be wholly ignored, and I went on to Heidelberg

[1] R. H. Chittenden, "The Development of Physiological Chemistry in the United States," p. 33, American Chemical Society Monograph Series. Chemical Catalogue Co., New York, 1930.

with the feeling deep in my heart that the place where such men as Gmelin, Tiedemann, Bunsen, Kirchoff, Helmholtz and Kühne had worked should give inspiration and opportunity, and that there would be found an environment more in harmony with my needs." Kühne had remembered the article in Liebig's *Annalen*, and welcomed him.

No one can read the opening chapters of Chittenden's monograph, "The Development of Physiological Chemistry in the United States," without realizing that the author began his work when the foundations of this science were being laid in this country, and through his own pioneer work did much to give the science the standing and place it now holds in the present academic scheme of things. Stimulated by his association with Kühne, Chittenden returned to New Haven fired with the idea that his laboratory should develop physiological chemistry as a broad biological course of study not restricted to the requirements of any branch of applied science (its use in medicine, for example) but devoted "to the expansion of physiological knowledge in all its varied aspects." His more immediate research interests were concerned with the requirements for the doctorate which were met in 1880 when he was given his Ph.D. degree by Yale. His appointment as professor of physiological chemistry came in 1882; this post was held for forty years when he retired as professor emeritus. In 1898 he assumed the directorship of Sheffield Scientific School and served in this capacity until his retirement in 1922.

Between 1875 and 1883 twelve papers were published reporting studies made in the new Laboratory of Physiological Chemistry. The year 1884 saw four papers through the press, one of them dealing with albumoses written jointly with Professor Kühne and published both in German in the *Zeitschrift für Biologie* and in English in the *American Chemical Journal*. The influence of the year spent at Heidelberg seems evident in the eleven publications that appeared in 1885, seven of which dealt with various aspects of amylolytic and proteolytic digestion. Students in this field will remember that it was Kühne who gave us the word *enzyme* (in yeast). Further development of the theme stands out in the ten papers found in the second volume of collected papers covering the year 1885–86, five of which report observations concerning digestion or the chemical properties of some of the products of proteolytic activity. Volume III of Collected Papers, covering the period 1887–88, comprised nine communications, four of them again related to this same topic. In similar fashion one might review the publications of each of the succeeding years and show that the predominant topic of interest was the phenomena of digestion.

To students of nutrition Chittenden is probably best remembered for his work on the amount of protein needed for proper maintenance of the adult organism. This problem attracted his attention in the autumn of 1902 and early part of 1903, when Mr. Horace Fletcher, the advocate of extensive chewing of food in order to secure from it the maximum of its nutritive value, spent several months in New Haven, "thereby giving an opportunity for studying his habits of life." This eventually led to nitrogen equilibrium studies on professional men (Chittenden and four colleagues in his laboratory), eight college students and thirteen volunteers from the U. S. Army. It was shown that nitrogen equilibrium can be maintained with a daily intake of protein "one-half of the 118 grams of proteide food called for daily by the ordinary dietary standards" (by which was meant here the Voit standard). These studies also led Chittenden to conclude that "body equilibrium can be maintained on far less than 3,000 calories per day by the brain worker." The detailed report of this investigation appeared in a volume entitled "Physiological Economy in Nutrition" published in 1905. These experiments were again reviewed and interpreted in relation to various aspects of nutrition in a set of eight lectures delivered before the Lowell Institute in Boston in the early part of 1907, and published in a book entitled "The Nutrition of Man." Examination of this latter volume shows that the experimental approach to the problem had been extended to include experiments on dogs.

During the administration of President Theodore Roosevelt, Dr. Chittenden was a member of the famous referee board that passed on the question whether sodium benzoate in foods is toxic. Another public service was rendered during World War I when he served as a member of the executive committee of the National Research Council. After the war he represented the United States on the Inter-Allied Scientific Food Commission, which met in London, Paris and Rome. As further examples of the international position which he held one may cite his membership in the Société des Sciences Medicales et Naturelles de Bruxelles and the fact that he was a corresponding member of the Société de Biologie in Paris.

Dr. Chittenden died in his eighty-seventh year and retained his mental faculties to the last. It was his good fortune, therefore, to see the subject to which very early he had chosen to devote his career develop in the work of two generations after his own. Such an opportunity is not given to many men. What he saw as the fruit of the labors of so many people in a field which he literally started in this country must have given him much personal satisfaction, for it constituted a vindication of his early judgment of the

possibilities in this science. In a very real sense he merited the title which many had conferred upon him years ago, namely, "The Father of Physiological Chemistry in the United States."

GEORGE R. COWGILL

DEATHS AND MEMORIALS

DR. EDWARD BENNETT MATHEWS, professor emeritus of mineralogy and petrography at the Johns Hopkins University, died on February 4 at the age of seventy-four years.

DR. WILLIAM GEORGE MACCALLUM, from 1917 until his retirement last spring professor of pathology at the Johns Hopkins University Medical School, died on February 3 at the age of sixty-nine years.

DR. EDWARD PEIRSON RICHARDSON, John Homans professor of surgery emeritus at the Harvard Medical School, died on January 26 at the age of sixty-two years.

DR. DANIEL M. MOLLOY, who from 1914 until his retirement in 1940 was a field representative in Central America for the International Health Division of the Rockefeller Foundation, died on January 29 at the age of sixty-one years.

ROY A. NORMAN, professor of heating and ventilation in the department of mechanical engineering of Iowa State College, died on January 29.

EDWIN R. PEARSON, for many years a member of the staff of the General Electric Company, where he was a designer of power transformers, died on January 28 at the age of eighty years.

AN anonymous gift of $10,400 has been made to Cornell University to establish a Veranus A. Moore Research Fund, the income of which will be used for research in the department of clinical and preventive medicine. The fund is in honor of the memory of Dr. Moore, who was formerly dean of the Veterinary College at the university.

IN the wish to express their appreciation and regard for Barbara Stoddard Burks, whose death has meant a great loss, personal and professional, to many psychologists and geneticists, her friends are establishing a memorial fund. Because of her activities during five years as chairman of the American Psychological Association Committee on Displaced Foreign Psychologists, it is proposed to use the fund to promote international professional relations among workers in the fields of psychology and genetics—for example, as a loan fund for assistance to European scholars studying or carrying on research in the United States. For the present the administration of the fund will be in the hands of a committee composed of Gordon Allport, Katherine Brehme, Robert Cook, Kurt Lewin, Theodore Newcomb, Lewis M. Terman, Ruth S. Tolman and Robert S. Woodworth. Contributions may be sent to Ruth S. Tolman, 4420 Fiftieth Street, N.W., Washington 16, D. C.

SCIENTIFIC EVENTS

BRITISH NEW YEAR HONORS[1]

THE New Year Honors include the names of a number of scientific workers and others associated with scientific work. The principal honors are as follows:

Knight of the Grand Cross of St. Michael and St. George: Sir George Gater, Permanent Under-Secretary of State, Colonial Office.

Companion of Honor: The Right Honorable R. S. Hudson, Minister of Agriculture and Fisheries.

Knight Commander of the Royal Victorian Order: Sir Harold Hartley, chairman of the Fuel Research Board.

Knights: Professor Ernest Barker, emeritus professor of political science in the University of Cambridge; Professor J. C. Drummond, scientific adviser to the Ministry of Food, professor of biochemistry in the University of London; Professor F. L. Engledow, professor of agriculture in the University of Cambridge; Dr. J. J. Fox, Government chemist; Professor F. R. Fraser, director-general of the Emergency Medical Services; W. T. Halcrow, engineering consultant, War Office; C. R. Lockhart, chairman of the East African Production and Supply Council; T. R. Merton, scientific adviser to the Ministry of Production, formerly professor of spectroscopy in the University of Oxford; J. G. Nicholson, deputy chairman, Imperial Chemical Industries, Ltd.

Companion of the Bath: P. N. Harvey, director of statistics and intelligence, Ministry of War Transport, Department of the Government Actuary; C. Nathan, principal assistant secretary, Ministry of Agriculture and Fisheries.

Companion of St. Michael and St. George: Right Rev. Mgr. C. Gagnon, rector of Laval University, Quebec, and E. B. Hosking, chief native commissioner, Kenya, and Dr. R. C. Wallace, principal and vice-chancellor of Queen's University, Kingston, Ontario, for services to university education.

Companion of the Order of the Indian Empire: Colonel R. H. Phillimore, superintendent of the Survey of India; M. Carbery, director of agriculture, Bengal; Sri Pattipati H. Rama Reddi, director of agriculture, Madras; D. B. Sothers, chief conservator of forests, Bombay.

Commander of the Order of the British Empire: W. A. Akers, a director of research, Department of Scientific and Industrial Research; Professor C. H. Best, professor of physiology in the University of Toronto, for important medical research; Major R. F. Brebner, chairman of di-

[1] From *Nature*.

rectors, Highland and Agricultural Society; Dr. A. N. Drury, director of the Lister Institute, lately a member of the scientific staff of the Medical Research Council; Dr. W. H. Glanville, director of the Road Research Station, Department of Scientific and Industrial Research; Professor D. A. L. Graham, professor of medicine and clinical medicine and dean of the Department of Medicine, University of Toronto, formerly president of the Royal College of Physicians and Surgeons of Canada, for important medical research; Dr. H. W. Meikie, H.M. historiographer in Scotland and librarian of the National Library in Scotland; W. Nairn, president of the Royal College of Veterinary Surgeons; J. M. Stewart, K.C., of Halifax, N. S., for services to university education and also as coal controller; C. Vaillancourt, of Levis, Quebec, for services to war finance and agriculture.

THE ELLA SACHS PLOTZ FOUNDATION FOR THE ADVANCEMENT OF SCIENTIFIC INVESTIGATION

DURING the twentieth year of the Ella Sachs Plotz Foundation for the Advancement of Scientific Investigation, eighteen applications for grants were received by the trustees, thirteen of which came from the United States, the other five coming from five different countries in Europe, Asia, North and South America.

In the twenty years of its existence the foundation has made four hundred and eighty-one grants which have been distributed to scientific men throughout the world.

The list of investigators with the purpose of the research aided in the current year is as follows:

Dr. Georg Barkan, School of Medicine of Boston University, continuation of investigations in the field of sulfanilamide derivatives and related compounds.

Dr. George A. Emerson, School of Medicine of West Virginia University, study of nutritional factors in susceptibility to lethal effects of anoxia.

Dr. Anna Goldfeder, New York University College of Medicine, continuation of studies on the relation between radiation effects and cell viability as indicated by induced resistance to transplanted tumors.

Dr. M. E. Hunter, Royal Victoria Hospital, Montreal, investigation of mild nutritional deficiencies in rheumatic fever.

Dr. Hermann Lehmann, Runwell Hospital, Essex, England, continuation of research on carbohydrate metabolism of isolated tissue.

Professor A. Lipschutz, Santiago de Chile, work on (1) the chemical structure of the steroids as related to antifibromatogenic activity; (2) the metabolic fate of fibromatogenic and antifibromatogenic steroids; (3) the fibromyoma of the prostatic region induced by estrogens in the guinea pig.

Dr. Edward P. Mumford, Stanford University, continuation of basic scientific research bearing on public health and the present emergency in the Pacific.

Dr. Hazel E. Munsell, Government of Puerto Rico School of Tropical Medicine, San Juan, study of the nutritional status, as regards vitamins, of sample populations of Puerto Rico.

Dr. Carl Neuberg, New York University, continuation of work on carbohydrate metabolism of microorganisms and animal cells.

Dr. Herbert Silvette, Medical School of the University of Virginia, investigations of the effect of low barometric pressure on renal function and on the action of drugs on the kidneys.

Thorndike Memorial Laboratory, Boston City Hospital, (Professor George R. Minot, director), in recognition of Dr. Francis W. Peabody's services to the foundation.

Professor Bernhard Zondek, Rothschild Hadassah Hospital, Jerusalem, continuation of investigations dealing with impairment and stimulation of the functions of the pituitary gland and especially of the gonadotropic hormone of the anterior pituitary lobe.

In their first statement regarding the purposes for which the fund would be used, the trustees expressed themselves as follows:

For the present, researches will be favored that are directed towards the solution of problems in medicine and surgery or in branches of science bearing on medicine and surgery.

As a rule, preference will be given to researches on a single problem or on closely allied problems; it is hoped that investigators in this and in other countries may be found, whose work on similar or related problems may be assisted so that more rapid progress may be made possible.

Grants may be used for the purchase of apparatus and supplies that are needed for special investigations, and for the payment of unusual expenses incident to such investigations, including technical assistance, but not for providing apparatus or materials which are ordinarily a part of laboratory equipment. Stipends for the support of investigators will be granted only under exceptional circumstances.

In the past few years the policy outlined in paragraph 2 has been neglected. Grants will be given in the sciences closely related to medicine without reference to special fields. The maximum size of grants will usually be less than $500. Applications should be sent to Dr. Joseph C. Aub, Massachusetts General Hospital, Fruit Street, Boston, Mass.

FUNGI FOR PENICILLIN PRODUCTION

A PROJECT is being organized at the University of Minnesota Agricultural Experiment Station, Division of Plant Pathology on Botany, to survey Penicillia belonging to the *Penicillium notatum* group and also species of *Aspergillus* for the production of penicillin. The project is under the supervision of Dr. E. C. Stakman. Cultures of organisms are desired, and individuals are requested to forward isolations of the groups of fungi mentioned to the laboratory indicated.

Isolations known to produce penicillin are especially desired.

Individuals who wish to survey other fungi for penicillin activity can obtain directions for a standard technique from the U. S. Department of Agriculture Regional Laboratory at Peoria, Illinois.

ALBERT L. ELDER,
War Production Board
Coordinator of Penicillin Program

THE NEW YORK BOTANICAL GARDEN

DR. WILLIAM J. ROBBINS, director of the New York Botanical Garden, speaking at the annual meeting of the garden in January, outlined the projects which had been approved by the City of New York shortly before the end of the year. The work to be done out of doors is in part necessitated by the widening of highways adjacent to the grounds of the garden.

Plans for rebuilding the Museum and Administration Building are being drawn under a contract awarded jointly to the firms of Aymar Embury II and of Skidmore, Owings and Merrill, architects. The remodeling of the building, erected forty-five years ago, is expected to cost $900,000. When added to improvements on the grounds this will bring the total expenditures for alterations to be carried out immediately after the war to the sum of $1,750,000.

The plans include the erection of a restaurant and comfort station north of the main conservatories, and complete re-landscaping of this area. Major Gilmore Clarke has been commissioned to prepare the final plans and specifications. His assignment also includes the re-designing of the system of roads and bridges through the grounds. His basic plan has already been approved by the Board of Managers. A new rose garden, the design of which was accepted at the annual meeting last year, will be established in the vicinity of the conservatories.

Preliminary plans for the reconstruction of the interior of the Museum and Administration Building call for a new main entrance which would lead visitors directly into a small museum on the ground floor. Most of the present museum exhibits will be stored for use as reference collections. The lecture hall, where many of the courses are given as well as the free lectures on Saturdays and occasional special conferences and programs, will be completely remodeled, with improved stage, seating, lighting, ventilation and projection equipment.

A self-service elevator is to be installed for the use of the staff. Increased space will be provided for the herbarium, which, with more than 2,000,000 specimens now on hand, is growing at the rate of nearly 40,000 specimens a year. The library of 50,000 bound volumes is increased each year by about 700 volumes and many thousands of periodicals, pamphlets, separates, etc. Additional office and working space for members of the staff, classrooms for lectures and laboratory practice, are also planned. Laboratories for plant pathology, physiology and genetics, in addition to rooms for photography and photostating, as in the present building, will be provided. There will be a rare book room for the library, and arrangements will be made for fumigating all herbarium specimens.

THE OPTICAL SOCIETY OF AMERICA

THE winter meeting of the Optical Society of America will be held at the Hotel Pennsylvania in New York City, on March 2, 3 and 4. The Inter-Society Color Council will meet on March 1, one day earlier, at the Hotel Pennsylvania. There will be a session for the discussion of Small Color Differences at 9:30 A.M., and an afternoon session at 2:30 P.M. for the discussion of other topics and the transaction of council business.

On Thursday, March 2, at 2 P.M. there will be a symposium of invited papers given before the Optical Society on the Ostwald Color System, and on Friday, March 3, at 10 A.M. a symposium of invited papers on "Infrared and Organic Chemistry." At 2 P.M. there will be a third symposium of "ten-minute" papers on "Infrared and Organic Chemistry."

On Friday evening an informal dinner is planned at which Dr. W. W. Coblentz, physicist of the National Bureau of Standards, will present some reminiscences. The dinner will be followed by an address by Dr. R. Bowling Barnes, director of the Division of Physics of the Stamford Research Laboratories of the American Cyanamid Company, who will speak on "Natural and Synthetic Rubber, Physical Methods of Analysis." There will be sessions for contributed papers on miscellaneous topics on Saturday.

The meeting will be open to non-members. Those who desire to receive the advance program or other information should address their requests to Dr. Arthur C. Hardy, Secretary, Optical Society of America, Massachusetts Institute of Technology, Cambridge 39, Massachusetts.

OFFICERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

OFFICERS of the American Association for the Advancement of Science have been elected as follows:

President:

Anton J. Carlson.

Vice-presidents:

Mathematics, J. L. Walsh, Harvard University.

Physics, Albert W. Hull, General Electric Co., Schenectady.

Chemistry, Arthur J. Hill, Yale University.

Astronomy, Seth B. Nicholson, Mt. Wilson Observatory.
Geology and Geography, Howard A. Meyerhoff, Yale University.
Zoology, George T. Hargitt, Duke University.
Botany, R. E. Cleland, Indiana University.
Anthropology, J. Alden Mason, University of Pennsylvania.
Psychology, Edward C. Tolman, University of California.
Social and Economic Sciences, Stanley D. Dodge, University of Michigan.
History and Philological Sciences, E. B. Krumbhaar, University of Pennsylvania.
Engineering, I. Melville Stein, Leeds and Northrup, Philadelphia.
Medical Sciences, Oswald T. Avery, Rockefeller Institute for Medical Research, New York.
Agriculture, R. J. Garber, U. S. Regional Laboratory, State College, Pa.
Education, Harold F. Clark, Columbia University.
Permanent Secretary, F. R. Moulton.
General Secretary, Otis W. Caldwell.
Treasurer, W. E. Wrather.
Director of Publications, F. L. Campbell.
Assistant Secretary, Sam Woodley.
Executive Committee: Burton E. Livingston, the Johns Hopkins University, *Chairman;* Roger Adams, the University of Illinois; Joseph W. Barker, Columbia University; Otis W. Caldwell, Boyce Thompson Institute for Plant Research; Walter B. Cannon, Harvard Medical School; Anton B. Carlson and Arthur H. Compton, University of Chicago; Kirtley F. Mather, Harvard University; F. R. Moulton, Elvin C. Stakman, University of Minnesota, and W. E. Wrather, U. S. Geological Survey.

SCIENTIFIC NOTES AND NEWS

DR. GEORGE HOWARD PARKER, professor of zoology emeritus of Harvard University, in recognition of his work for the advancement of zoology, has been elected a foreign member of the Zoological Society of London.

THREE of the four Charles Mayer fellowships of the New York Academy of Medicine, each of the value of $2,000, for "the study of the relationship between precancerous lesions of the mouth, hepatic insufficiency and gastrointestinal disorders," have been awarded to Dr. Harry Goldblatt, professor of experimental pathology at the School of Medicine of Western Reserve University; to the Cancer Research Laboratory of the Mount Sinai Hospital, New York, and to Dr. John R. Murlin, professor of physiology at the University of Rochester. Further applications should be sent to Dr. Mahlon Ashford, secretary of the committee, 2 East 103rd Street, New York, not later than April 1.

THE Institute of the Aeronautical Sciences has, as already announced, elected Major R. H. Fleet, of San Diego, president. Vice-presidents elected are Wellwood E. Beall, vice-president of the Boeing Aircraft Company; William K. Ebel, vice-president of Glenn L. Martin Company; Elmer A. Sperry, Jr., vice-president of the Sperry Products, Inc.; and G. M. Williams, vice-president of the Curtiss-Wright Corporation. Bennett H. Horchler has been made executive vice-president; Charles H. Colvin, director of the Daniel Guggenheim School of Aeronautics of New York University, treasurer; Robert R. Dexter, secretary, and Lester D. Gardner, chairman of the council and president of the Aeronautical Archives.

DR. GERTRUDE RAND, of the Institute of Ophthalmology of the Presbyterian Hospital, New York City, was the guest of honor on February 7 at a tea meeting at the Hotel Ritz-Carlton, New York City, of the Residence Lighting Forum of the New York Section of the American Illuminating Engineering Society. Dr. Rand spoke on her work on artificial lighting and its relation to the practical study of lighting and vision. George Ainsworth, architect, designer and illuminating engineer, spoke on the practical application of these researches to the lighting of interiors.

THE following have been elected officers for 1944 of the Mineralogical Society of America: *President,* R. C. Emmons, University of Wisconsin; *Vice-president,* Harry Berman, Harvard University; *Editor,* Walter F. Hunt, University of Michigan; *Treasurer,* Earl Ingerson, Geophysical Laboratory, Washington, D. C.; *Secretary,* Paul F. Kerr, Columbia University, and *Councilor, 1944–47,* S. J. Shand, Columbia University.

JOHN H. MONTGOMERY, of Fritzsche Bros., Inc., was elected at the annual meeting on January 15 president of the Essential Oil Association of the United States of America.

R. W. MARSH, of the Long Ashton Research Station, has been elected president for 1944 of the British Mycological Society.

DR. G. WATTS CUNNINGHAM, Susan Linn Sage professor of philosophy at Cornell University, has been appointed dean of the Graduate School. He succeeds Professor G. H. Sabine, now vice-president of the university. Dr. Cunningham has been professor of philosophy at the university since 1927. Dr. Philip A. Munz, dean of the faculty of Pomona College, has been appointed, effective on July 1, professor of botany and horticulture in the Bailey Hortorium.

DR. JOHN G. KIDD has been appointed professor of pathology at the Cornell University Medical College and pathologist of the New York Hospital.

DR. JOSEPH E. MARKEE, professor of anatomy at Stanford University, has been made professor and head of the department of anatomy of the School of Medicine of Duke University.

DR. F. P. LUDUENA, of the medical faculty of the University of Rosario, Argentina, has become assistant professor in the department of pharmacology of the Medical School of Stanford University, San Francisco, and Dr. Robert H. Dreisbach has been appointed instructor.

T. THOMSON, lecturer in the School of Forestry of the University College of North Wales, Bangor, has been appointed the first incumbent of the newly established chair of forestry.

EUGENE PAUL POLUSHKIN has been appointed associate professor of metallurgy at the Stevens Institute of Technology, and Dr. Frances Hurd Clark has been named assistant professor of powder metallurgy.

FRANK M. STEAD, associate professor of sanitation at the School of Medicine at Galveston of the University of Texas, has resigned to take charge of studies on industrial hygiene for the California State Board of Health at Berkeley. He will be succeeded by Joe B. Winton, formerly associated with the Harris County Health Department. Dr. J. Allen Scott, senior statistician in the Division of Vital Statistics in the U. S. Bureau of the Census, formerly on the staff of the Rockefeller Foundation in Egypt, has been appointed associate professor of preventive medicine in the field of statistics and epidemiology.

DR. W. SHERWOOD LAWRENCE, instructor at the Medical School of Stanford University, San Francisco, has been appointed associate pharmacologist to the Food and Drug Administration, Washington.

DR. FRED W. OBERST, of the U. S. Public Health Service Hospital at Lexington, Ky., where he was engaged in biological research on narcotics, has been made head of the newly organized department of biochemistry of the Wm. S. Merrell Research Laboratories, Cincinnati, Ohio.

WILLIAM A. LEWIS, director of the school of electrical engineering of Cornell University, has become consulting electrical engineer to the Armour Research Foundation at the Illinois Institute of Technology and has been named research professor in the department of electrical engineering. Fred J. Vogel, who has been associated with the Westinghouse Electric and Manufacturing Company for the past twenty-four years and who has specialized in the development of power transformers, became professor of electrical engineering on December 1.

DR. HUGH R. STILES, of the department of research in biology of the Commercial Solvents Company, has been appointed head of the newly organized agricultural division, with headquarters at Terre Haute, Ind.

WILLIAM B. LODGE, recently associate director of the division of war research of the Airborne Instruments Laboratory of Columbia University, has been named acting director of the department of engineering of the Columbia Broadcasting System.

THE Council of the British Cotton Industry Research Association has announced that Dr. F. C. Toy has been appointed to succeed Sir Robert Pickard, who is relinquishing the post of director of research that he has filled for the last seventeen years. Dr. D. W. Hill succeeds Dr. Toy as deputy director, and Sir Robert Pickard will be consultant to the association.

DR. HENRY E. MELENEY, Hermann M. Biggs professor of preventive medicine, New York University College of Medicine, visited Puerto Rico during the week of January 9 as guest of the Puerto Rican Medical Association and the School of Tropical Medicine at San Juan. He addressed the medical association on "Recent Advances in the Treatment of Malaria," and the School of Tropical Medicine on "The Relationship of Clinical Amoebiasis to Various Strains and Growth Requirements of *Endamoeba histolytica*." On his return through Cuba he addressed a special meeting of the Cuban Branch of the American Public Health Association and the Cuban Society of Preventive Medicine on "Inter-American Cooperation in Medicine and Public Health."

PROFESSOR I. E. MELHUS and Professor George Goodman, of the department of botany of Iowa State College, have left on an expedition to southern Mexico and northern Guatemala to make a collection and study of varieties of corn. This research is supported by a gift of $75,000 from the Earl E. May Seed Company of Shenandoah, Iowa.

PROFESSOR P. J. W. DEBYE, professor of chemistry at Cornell University, has leave of absence from February 13 to March 20 to enable him to conduct a lecture tour for the Society of the Sigma Xi.

WORD has been received by Dr. T. H. Goodspeed, professor of botany and director of the botanical garden of the University of California at Berkeley, who visited South America last year, of a presidential decree authorizing acquisition of the site selected by him at the request of President Rios, and stating that it would be developed according to the specifications he made at that time. The garden will be close to the

city of Valparaiso and will contain five hundred acres of hilly terrain near the sea where there is still a considerable amount of native vegetation. Fifty acres will receive the more intensive development of the conventional botanical garden and will include examples of the most important plant families, particularly the species of those families native to Chile. There will also be an area for Chilean trees and shrubs, one for water plants, another for cacti and other desert plants. The remainder of the area will be a plant preserve where future generations will be able to see and study elements of the native vegetation of central Chile.

A PORTRAIT of Nicholas Copernicus, which was painted by Maxim Kopf early last year in connection with the four hundredth anniversary of his death, was formally presented on February 3 to Dr. Harlow Shapley for the Harvard College Observatory by Dr. Stephen P. Mizwa, executive director of the Kosciuszko Foundation. The painting, which measures 48 × 54 inches and is done in oils, was presented at a regular meeting at the observatory of the Bond Astronomical Club. In presenting the portrait Dr. Mizwa spoke on the "Quadricentennial Tribute to Copernicus" and after acceptance of the gift, Dr. Shapley gave an address on the "Revision of Globular Star Clusters."

THE sixth winter meeting of the Industrial Research Institute was held on January 28 and 29, at the Westchester Country Club, Rye, N. Y. A hundred research executives and a number of presidents and vice-presidents of member companies and their guests attended. Louis Ruthenberg, president of Servel, Inc., Evansville, Ind., was the principal speaker at an informal dinner on Friday evening. His subject was "Industrial Research under Free Enterprise."

THE Society of the Sigma Xi is encouraging member group activity in non-academic research institutions that qualify because of their participation in, and encouragement of, original research in science. The first group to qualify and to be granted affiliation with Sigma Xi is the Esso Research Club, of Elizabeth, N. J., whose membership is drawn from the chemists, physicists, engineers and other technical research and development personnel of the companies associated with Standard Oil Company of New Jersey. Arrangements are being made for the installation on April 26 of the Esso Research Club by the national officers of Sigma Xi.

THE sixth National Geographic Society-Smithsonian Institution Archeological Expedition to southern Mexico, led by Dr. Matthew W. Stirling, chief of the Bureau of American Ethnology, left Washington on January 28 to continue the study of pre-Columbian civilizations. The object of the expedition this year is an archeological survey of the headwater streams of the Tonalá River in the Tabasco, Veracruz, Chiapas and Oaxaca States. Last year a native told Dr. Stirling about a large ruin in the region. No explorer has ever visited the site. The expedition made an unsuccessful attempt to find the ruin, but, with data now in hand it is hoped to reach it for preliminary examination.

IT is planned in the near future to open a new College of Engineering at the University of California at Los Angeles. A curriculum in pre-engineering, open to freshmen and sophomores, has already been established. It is expected that curricula in various branches of engineering science will be introduced after the appointment of a dean for the college. First emphasis will be placed on practical aspects of aeronautical engineering.

A WINTHROP fellowship in pharmacology has been established at the Stanford University School of Medicine for use in training doctors of medicine in teaching or research in the field of pharmacology. The fellowship is to be financed by a grant of $1,500 from the Winthrop Chemical Company of New York City. An initial instalment of $375 has been received from Dr. J. P. Rice, director of medical research of the company.

The New York Times reports that preparations are underway to convert Winfield Hall, the Long Island Sound estate of the late Frank W. Woolworth, into a chemical and metallurgical institute where university and commercial scientists will assemble for research and conferences to exchange information. Provision will be made for them to live in the residence of the late owner for months at a time. No industrial activities will be conducted at the research center, but limited laboratory facilities will be available in one of the outbuildings for analytical and experimental work for the benefit of industrial chemistry and metallurgy. The legal occupant will be the Reynolds Research Institute, formed by the Reynolds Metals Company and associates. The head of the company, Richard S. Reynolds, Jr., is president of the institute. Application has been made to the Glen Cove Zoning Board for permission to install the institute on the property, which is now assessed at about $200,000.

IT is reported in *Nature* that a Soviet scientific commission is now in Novosibirsk organizing a Western Siberian branch of the Academy of Sciences of the U.S.S.R. The academy will establish four institutes in the city: for chemistry and metallurgy, mining and geology, medicine and biology, and transport and power

MCGILL UNIVERSITY has established a department

of psychiatry and, in association with the Royal Victoria Hospital, Montreal, an institute for research and teaching. Through the generosity of Sir Montagu and Lady Allan, a building and an extensive site have been provided. Facilities for intensive treatment are being set up. The development of research and treatment will be major objectives, and with this in view large and well-equipped laboratories are to be provided. The project is being supported both by the Rockefeller Foundation and by the Government of the Province of Quebec. Dr. D. Ewen Cameron has been appointed to the chair of psychiatry and will also be the director of the institute.

ACCORDING to a cable to *The New York Times* under date of January 26, the Royal Observatory built at Greenwich in 1675 is probably going to be moved. Sir Harold Spencer Jones, Astronomer Royal, is reported to have said that the proposal of moving has been approved in principle by the Admiralty, but that nothing definite can be done until the King sanctions it. After that the British Treasury will have to be consulted. Sir Harold said in explanation: "We must face the fact that Greenwich is no longer suitable. We used to have a greater record of sunshine than Kew. Now the annual total sunshine at Greenwich is something like 200 hours less than Kew. When the sun gets low sunlight is so weakened by smoky atmosphere that it is impossible to get registrations on the sunshine recorder."

DISCUSSION

THE GENETIC SEX OF INTERSEXUAL GOATS AND A PROBABLE LINKAGE WITH THE GENE FOR HORNLESSNESS

IN the Beltsville herd of goats, according to Eaton and Simmons,[1] the Saanen breed produced 11.1 per cent. of intersexes and the Toggenburgs 6 per cent. Paget[2] has found 14.3 per cent. intersexes in the British Saanen breed, but his figure is probably high representing the incidence in herds where the condition has become a serious problem. At Beltsville, the sex ratio was for Saanens 49.3 per cent. males, 39.6 per cent. females and 11.0 per cent. intersexes; for Toggenburgs it was 46.4 per cent. male, 47.6 per cent. females and 6.0 per cent. intersexes. Paget found 193 males, 105 females and 52 intersexes, but his figure for intersexes includes only those kids which were visibly intersexual at birth. The sex ratio in both sets of data is much more normal if the intersexes are regarded as modified females. If this interpretation is correct it would appear that the gene for intersexuality acts only upon the female so that the percentage of intersexes should be doubled to produce the true number of double recessives. Eaton and Simmons furnished strong evidence that the condition is inherited as a simple recessive. If so, some homozygous recessive males should exist which in certain matings would produce 50 per cent. males, 25 per cent. females and 25 per cent. intersexes. Perhaps this may account for the high incidence in Paget's data, higher than that expected in a Hh × Hh mating, if all intersexes are genetic females.

The suggestion that the intersexes are modified females is in line with other evidence. In vertebrates modification of sex is almost always from female to male, extremely rarely from male to female. Evidently intersexuality is produced by the survival and development of the primary sex cords in the genetic female and not by the growth of secondary cords in the genetic male. The genetic male lacks the possibility of producing the necessary second ingrowth of sex cords.

Some years ago the writer observed that all the intersexual goats he had seen (about 200 now) were hornless. Hornlessness is inherited as a simple dominant. Since then much inquiry and observation have failed to unearth a single horned intersex. If they exist they must be very rare. This suggests that there is a close linkage between the two genes, an important point economically, since selection for hornlessness has been practised by pedigree goat breeders for some time. The goat breeders have evidently been increasing the gene frequency for intersex by selecting for hornlessness and are thus doing themselves harm.

S. A. ASDELL

CORNELL UNIVERSITY

[1] O. N. Eaton and V. L. Simmons, *Jour. Heredity*, 30: 261, 1939.

[2] R. F. Paget, *Monthly Jour. British Goat Society*, 36: 57, 1943.

FUNGUS INFECTION OF EGGS OF THE BLUE CRAB CALLINECTES SAPIDUS RATHBUN

IN 1941 Dr. Margaret Lochhead, working at this laboratory, observed a fungus-like organism on eggs of blue crabs taken directly from the water and from commercial catches. During the summers of 1942 and 1943 the writers began a program of study aimed to establish the identity of the infection, its effect on the hatching of the eggs, the percentage of crabs in the commercial catches that is infected and the distribution of the infection in Tidewater Virginia.

Professor John N. Couch kindly examined the infected eggs and identified the fungi as *Lagenidium callinectes* Couch, the primary parasite, and *Rhizophidium,* sp., which may be either parasitic or saprophytic (Couch, 1942).[1]

Experimental data indicate that infected eggs are usually below the normal size. Whereas uninfected eggs under optimum conditions in the laboratory gave a 70 to 90 per cent. hatch of normal first-stage zoeae, fungus-infected eggs under similar environmental conditions either failed to develop to the hatching stage or hatched into prezoeae, considered to be abnormal. The prezoeae rarely survived longer than forty-eight hours.

In 1942 infected and uninfected egg masses were suspended in the York River to determine the effect of the fungi on egg development under natural conditions. The infected eggs failed to hatch, and the fungus grew considerably. The uninfected egg masses showed an abundance of empty egg cases, indicating a fairly normal hatch.

The fungus appears to be quite uniformly distributed throughout the egg masses and is present in eggs in all stages of development.

Random samples of eggs have been examined from widely separated parts of Tidewater Virginia, namely, Rappahannock River, York River, Hampton Roads and Lynnhaven. The results to date indicate marked regional variations in the per cent. of infection.

The parasitic fungi represent an important biological factor that occupies a place with certain physical factors, such as low salinity, that are known to greatly reduce the per cent. of hatch (Sandoz and Rogers).[2] In light of the hatching results obtained, the value of protecting heavily infected egg-bearing crabs against commercial use appears questionable. Therefore, in selecting and evaluating a crab sanctuary for the protection of brood stock, attention should be given to determining the extent of parasitic fungus infection present as well as the suitability of the physical and chemical conditions that characterize the area.

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[1] John N. Couch, *J. Elisha Mitchell Scien. Soc.,* Vol. 58, No. 2, December, 1942.

[2] Mildred D. Sandoz and Rosalie Rogers, *Ecology* (in press).

VITAMIN C IN THE NEEDLES OF SOME CONIFERS

SINCE the report of Shishkin published recently in SCIENCE[1] "that needles of ordinary pine trees contain large quantities of vitamin C," some authors (Dunham,[2] B. Schick,[3] Ch. Macnamara[3] and M. Donnelly[4] have called attention to the fact that the decoction of the needles of the evergreen tree was used with success against scurvy in the early expedition of Jacques Cartier in 1535 and further in the war between Sweden and Russia (1708–09).

This fact has suggested to us the investigation of the vitamin C content of the decoction of some conifers (needles), principally those growing largely in Southern Brazil (Araucaria, Podocarpus).

The determinations were performed on a 5 per cent. extract prepared by boiling the ground leaves with water, as is generally done in the preparation of tea. In other cases the leaves were ground and extracted with 2 per cent. metaphosphoric acid. The determinations were carried out before and after the treatment with H_2S and CO_2.

Tillmans' 2,6-dichlorophenolindophenol titration method was employed. We are indebted to Dr. F. R. Milanez, of the Biological Department of the Rio de Janeiro Botanical Garden, for the samples used in these analyses.

A brief summary of our results is shown in Table 1.

TABLE 1

No. of samples	Species	mg per 100 ml of the extract: ascorbic acid	mg per 100 ml of the extract: dehydroascorbic acid
5	*Araucaria augustifolia (brasiliensis)*	2.7	1.0
5	*Podocarpus Sellowii*	3.3	1.3
1	*Podocarpus Lambertii*	2.8	1.9
2	*Araucaria excelsa*	0.5	0.8
1	*Pinus excelsa*	2.3	1.0

Although ascorbic acid is not present in the decoction in large amounts, the use of the pine-tea would be helpful in some countries where the vitamin C is not readily available.

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THE TWILIGHT CEREMONIES OF HORSEFLIES AND BIRDS

IN a recent number of SCIENCE[1] Leonard Haseman published an article on "The Courting Flights of Tabanids," describing a humming, hovering flight of horseflies which is performed by the males alone and only at the twilight hour. I wish to point out that

[1] SCIENCE, April 16, 1943, pp. 354–355.
[2] *Ibid.*, August 6, 1943, p. 132.
[3] *Ibid.*, September 10, 1943, pp. 241–242.
[4] *Ibid.*, October 8, 1943, p. 325.
[1] L. Haseman, SCIENCE, 97: 285, 1943.

this performance of the horseflies is, in its duration and time of occurrence, fundamentally similar to the twilight song of birds. Haseman tells us that in *Tabanus sulcifrons* the performance begins very early in the morning, at a low intensity of light, "a fraction of one foot-candle," and continues for a definite period, "20 to 25 minutes," until the light has reached an intensity of three to five foot-candles; the flight then ceases more or less abruptly. As the season advances, bringing a change in the hours of twilight and sunrise, the hour of the flight changes accordingly. All these details of the horsefly's performance are found, essentially the same, in the twilight song of birds.

Haseman speaks of the twilight flights of the horseflies as "courting" flights; but while the males were performing the twilight flight he could find no females among them and no pairs coupling. Mosier and Snyder[2] express doubt as to whether the early morning flight of *T. americanus* is a courting flight. Hine,[3] in Ohio, found that the mating of *T. sulcifrons* occurred in a very restricted period, about 8 to 8:30 A.M., Standard Time, which would be some three hours or more after the early morning flight. Accordingly, instead of calling the twilight performance of the horseflies a "courting" flight, would it not be well to name it "the twilight hovering flight"?

There is much evidence to indicate that the twilight song of birds has little or no connection with mating. Even if it has a slight connection with mating, that fact can not account for the exact relation of the song to the hours of twilight. Why birds sing a twilight song is not completely understood, but the song has some relation to the bird's daily cycle, his seasonal cycle and his photoperiodism.

We shall speak especially of the daily cycle of the wood pewee, a species of bird whose song is most suitable for statistical study (see the monograph on "The Song of the Wood Pewee").[4] In this species the daily cycle is symmetrical; the male sings a twilight song both morning and evening, and in certain important details the order of events in the morning song is reversed in the evening song, so that the latter is a "mirror image" of the former.

This symmetrical daily cycle anticipates the solar day, being about 17 minutes ahead of it. In other words, the birds keep "daylight-saving time"; but the bird's chronometer is only 17 minutes ahead of the sun, instead of 60 minutes like ours. In the morning the wood pewee anticipates the dawn by beginning to sing when the light intensity is extremely low (about 0.01 foot-candle). In the evening he anticipates nightfall by ending his song while there is still considerable daylight (about two foot-candles).

In saying that the bird "anticipates" the dawn we are not raising the question whether he has any conscious expectation of it. We state only that he acts ahead of time. Every one knows that organisms anticipate the seasons. In the springtime trees often put forth their flowers and leaves before the weather is suitable. In the autumn many birds begin their migration in August; in doing so they are anticipating winter unconsciously, for they certainly do not know that winter is coming. Anticipation, in the sense of acting beforehand, is one of the fundamental properties of life.

We stated that the wood pewee's chronometer is 17 minutes fast, as compared with sun time. We shall explain briefly how the number 17 is derived from our data. In the morning the wood pewee begins to sing at S.d.9°36′. (S.d. = Sun's depression, the vertical angular distance of the sun below the horizon.) In the evening he ends his song at S.d.4°40′. The average of these two is practically S.d.7°, and we regard this as the main dividing point between day and night, for the wood pewee. In the morning he begins to sing 17 minutes before S.d.7°, and in the evening he ends his song 17 minutes before S.d.7°. That gives two measuring points at which the wood pewee anticipates the sun by 17 minutes; and in the monograph cited[4] I have described also four other measuring points which support the conclusion that his daily cycle is 17 minutes earlier than the solar day.

A great many species of songbirds, perhaps all species, anticipate the solar day. Apparently the same is true of the horseflies. Unfortunately, we have no data for both morning and evening from the same species of horsefly. The authors quoted have observed the twilight hovering flight of *T. sulcifrons* and *T. americanus* only in the morning, and *T. giganteus* only in the evening. In regard to this evening performer, Haseman says, "This species seemed to require more light, as they began . . . with a light intensity of about 30 foot-candles and continued for some thirty minutes, ceasing when the light had dropped to an average of about 3 foot-candles." I suggest that this difference in regard to intensity of light is not an inter-specific difference, or not purely such; it is a difference between the morning and the evening performance. If this interpretation is correct, the horseflies do anticipate the solar day. It is to be hoped that field entomologists will find out if *T. sulcifrons* or *T. americanus* ever performs in the evening, or *T. giganteus* in the morning; if so, this will give opportunity to answer definitely the question of their anticipation of the solar day.

WALLACE CRAIG

ALBANY, N. Y.

[2] Mosier and Snyder, *Proc. Ent. Soc. Wash.*, 20: 115, 1918.

[3] J. S. Hine, U. S. Dept. Agr. Bur. Ent. Tech. Ser., No. 12, Part II, p. 24, 1906. (Haseman's citation of Hine is not quite correct.)

[4] W. Craig, *N. Y. State Mus. Bull.*, No. 334, 1943.

SCIENTIFIC BOOKS

RULES OF GEOGRAPHIC VARIATION

Darwinism and Geographic Regularities in Variation of Organisms. By E. I. LUKIN. 311 pp. In Russian. Academy of Sciences of U.S.S.R., Moscow-Leningrad.

THE existence of rules in the geographic variation of organisms has been known for more than a century, but until recently these rules were exploited chiefly by Lamarckians as a support for their views. About ten years ago, B. Rensch, himself originally a Lamarckian, conceded that the rules may as well or better be interpreted in accordance with the theory of natural selection. E. I. Lukin, professor of the University of Tomsk, completes the process by insisting that the facts described by these rules are contrary to any form of Lamarckism and compatible only with selectionism. To this reviewer, Lukin's arguments are convincing. But whether one agrees with Lukin or not, there is no doubt that his book, dated December, 1940, but only now received in this country, is the best on the subject in any language. It must be noted in particular that Lukin reviews numerous investigations published by various authors during the last decade and a half in Russian journals which are difficult of access even for those American biologists who read Russian; this fact alone would make the book valuable.

The book consists of three parts—a historical introduction, a summary of the evidence and a general interpretation. The following rules are discussed: (1) Bergmann's rule—in warm-blooded vertebrates races characterized by small body sizes are found usually in the southern, warmer parts of the species ranges, and large races in colder northern parts. Whether or not this rule is applicable to poikilothermal animals is uncertain. (2) In higher plants tall races occur chiefly in humid and short races in drier countries (based on investigations of O. K. Fortunatova). (3) Allen's rule—in mammals and birds the protruding body parts are relatively longer in warm and shorter in cold countries. (4) Gloger's rule—melanin pigmentation in mammals and birds increases in warm and humid and the phaeomelanin pigmentation in arid countries. (5) Darkly pigmented races of insects are found in countries with humid and lightly pigmented races in countries with arid climates. (6) The studies of K. S. Maslova show that the glumes of wheat varieties develop a red pigmentation in countries with much precipitation during the period of the ear development and a black pigmentation in countries which are dry and hot during the same periods. (7) Plants of warm countries form fats which contain greater proportions of saturated fatty acids, while plants of cold countries produce greater proportions of unsaturated fatty acids (N. N. Ivanov and many others). (8) Optimal temperatures for the development of soil bacteria are higher in warm than in cold countries (E. N. Mishustin and others); similar relationships are observed in many animal and plant species. (9) Races of mammals which inhabit localities at high elevations have more erythrocytes and more hemoglobin in their blood than do races of low altitudes; increases of the numbers of erythrocytes and of the amounts of hemoglobin occur when individuals born at low elevations are transferred to high altitudes. N. I. Kalabukhov has, however, shown that no decrease of the number of erythrocytes or of the amount of hemoglobin is observed if the high altitude race of the rodent *Apodemus sylvaticus ciscaucasicus* is kept at a low altitude (the corresponding increases are observed following the transfer of the low altitude race of the same species to the alpine zone). (10) Tropical and subtropical plants are mostly "short day," and temperate zone and subpolar species are mostly "long day" plants; exceptions from this rule are mostly explicable if one takes into account the special biological peculiarities of the respective species.

Every one of the above rules as well as many other facts quoted in the book show, according to Professor Lukin, that the process of race formation is governed by natural selection. The arguments of Lukin, sometimes couched in a sharp polemic language, are invariably interesting and frequently brilliant. His general ideas about evolution are based on the conceptions of modern genetics. This is especially gratifying as a sign that the misguided campaign against genetics waged by the partisans of T. D. Lysenko has spent itself. An echo of this campaign may perhaps be perceived in Lukin's attitude toward Darwin and his selection theory, expressed in several statements such as the following: "First of all, Darwinism is the only right theory, which has splendidly explained the fundamental moving agents of the organic development. Hence, any evolutionary problem may be solved only in the light of Darwinism." What, however, is Darwinism? Darwin himself modified and developed his views during his lifetime. Then came the period of neo-Darwinism with Weismann as the leading representative. In the last decade or two the progress of genetics has led to theories of evolution which this reviewer proposed to label "inductive Darwinism." We may claim for the modern theories an unbroken ideological succession from Darwin's heritage, but we need not go as far as to regard all Darwin's views inviolable. Like any living scientific theory, that of Darwin has changed greatly, and we may only hope that it will continue to evolve and

change further. Probably the most important change which has and is taking place and which should be welcomed is that evolution theories are being removed from the realm of abstract speculations and placed on experimental and quantitative basis.

Among the concluding chapters of Lukin's book, that devoted to a consideration of the parallelism between the phenotypic and the genotypic variability is most interesting. It is well known that organisms frequently respond to environmental changes by adaptive phenotypic modifications; yet the same adaptive characters may be genotypically fixed in races normally living in the corresponding environments (see the above quoted example of the changes in the composition of the blood in low altitude and high altitude mammals). Adaptation may be attained either by development of a norm of reaction which responds favorably to the variety of external conditions in which the species usually occurs or else by development of a variety of genotypes with specialized norms of reaction fitting the different ecological niches. Lukin points out that the history of the species and its biology determine which one of these two methods of adaptation is more efficient. Genotypic specialization is preferable to phenotypic plasticity where an early appearance of an adaptive character in the ontogeny is desirable. For example, skin callosities may develop either as a response of the skin to pressure or as a genetically fixed character arising already in embryos without the stimulus of pressure. The former method exposes the animal to risks during the process of formation of callosities, while the latter protects it from the birth on. Phyletic advances are usually accompanied by genotypic specialization. According to Mashkovcev, the lung development in lower amphibians (axolotl) depends on the functional stimulus of respiration by air; in higher ones the lung development is partly (in frogs) or completely (toad) independent of functional stimuli.

TH. DOBZHANSKY

COLUMBIA UNIVERSITY

THE STUDY OF POLLEN IN PEAT

An Introduction to Pollen Analysis (with a foreword by Roger P. Wodehouse). By G. ERDTMAN. 239 pp., 28 plates, 3 portrait plates, 15 text figs., some multiple; new series Plant Science Books, vol. 12; Waltham, Mass.: Chronica Botanica Company; New York: G. E. Stechert and Company. 1943. $5.00.

THE well-known and much-admired Swedish botanist, G. Erdtman, here gives to the world a partial harvest of the many years that he has devoted to the study of pollen analysis. This branch of botanical-geological science stems from the resistance to decay of the cuticle of pollen grains, entrapped in the peaty deposits of swamps, or, to a large extent, in fine-grained muds, silts and sands deposited by various agencies. As peat bogs afford an almost perfect trap for pollen, the preserved pollen represents the pollen rains throughout the period of growth of the bog. Pollen analysis is the process of study of the stratigraphic distribution of pollen, its separation from decayed vegetable matter and mineral grains, its identification and the interpretation of results in terms of the environment of the bog throughout its history. The pollen of plants growing on or near the borders of the bog records the local conditions, whereas pollen of upland plants reflects the ecology of the general neighborhood and hence the climate of the time. In practice 150 grains of tree pollen are counted from each sample in a vertical peat section. Percentages of the tree pollen, omitting corylloid pollen, are calculated and plotted in a graph. Increase or decrease is considered much more significant than absolute percentage of any tree species. Opposite trends, as of spruce and of mixed hardwoods, are considered of the highest importance as indicating a pronounced change in the forest association and hence in climate.

The discovery of these relationships is a noble scientific accomplishment in which Swedish scientists have taken a leading part. Erdtman's historical account somewhat overemphasizes the accomplishments of his countrymen. Nevertheless, it is perhaps fair enough to say that the systematic attack on paleoclimatological problems by means of pollen analysis of bogs dates from von Post's paper of 1916 and is based largely on Lagerheim's techniques. Since 1916, activity in the field has been astonishing. Erdtman's useful biennial bibliographies record an average of 150 papers a year in Europe alone, with contributions from all over the world. The study of the Postglacial and Interglacial peats absorbs most of the workers, but the pollen of the Tropics and of Tertiary and Cretaceous coals, as well as the spores of Cretaceous and Carboniferous coals afford opportunities for researches of great botanical interest.

Erdtman's book is primarily a manual for botanists and contains chapters on the chemistry of peat by E. Erdtman, on field and laboratory methods for the collection and preservation of fresh and fossil pollen, on the identification of pollen and on methods of presenting an analysis. Important to botanists are six chapters devoted to the morphology and identification of pollen with elaborate references to the literature.

The discussion of the output and dissemination of pollen, the composition of pollen rains, the distance of transport and loss of pollen by decay is presented with ample references to the literature. Here is the heart of the subject, the area in which the greatest possible errors lie. Unfortunately the author is not so

critical, dispassionate or comprehensive as might be desired. To one acquainted with the subject, his remarks are perhaps adequate, but proof of the assumption that the pollen analysis represents with sufficient accuracy the pollen rain is not clear-cut and convincing. The errors of sampling and treatment of samples are not sufficiently differentiated from errors arising from the imperfections of the pollen record. Perhaps these matters are reserved for a later book on the stratigraphy and paleoclimatology of bogs. Indeed, it may not be possible to discuss all these matters in so brief a space. The absence of a truly critical discussion will leave those whose interest is paleoclimatological and chronological disappointed.

As a manual for the practicing pollen analyst or as a text-book for the aspiring student, the book will find its greatest usefulness. We can be grateful to the editor and his volunteer assistants for successful solution of the problems involved in publishing a text with the author isolated by the war. Errors seem to be at a minimum, but redrawing of some of the illustrations would have been helpful.

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SPECIAL ARTICLES

CORN GERM: A VALUABLE PROTEIN FOOD

IN times of food stringency, such as are with us now and will stay with us until the havoc of war has subsided, the most economical use of available food supplies is imperative, and the introduction of new food materials should be welcome. Cowgill[1] has recently emphasized the importance of supplementing available foods by new or little-used foods, the nutritive value of which has been demonstrated by research precipitated by the war. This note calls attention to the value of corn germ as a potentially valuable protein food in human nutrition. The potential output of defatted corn germ, based on the crop yield of 1942, assuming a processing of 16 per cent. of the crop by dry milling and distilling,[2] and a yield of 7 per cent. of germ, has been estimated[3] at 1,000 million pounds per year.

The nutritive value of the proteins of the corn germ has not been studied by any method, in so far as the authors are aware. The potential availability of this food product in human nutrition warrants a better understanding of its nutritive properties. We therefore undertook a study of the digestibility and biological value of corn germ proteins, using the nitrogen balance method that has been developed in this laboratory.[4,5]

The sample of defatted corn germ tested[6] was solvent-extracted at low temperatures (less than 75° C.) and analyzed as follows: 93.06 per cent. dry matter, 2.94 per cent. ether extract, 4.18 per cent. crude fiber, 21.19 per cent. protein (N × 6.25), and 25.6 micrograms of thiamine per gram. The biological value of the protein in this product was measured with a group of 10 young albino rats with initial weights of about 70 grams, and was compared, by a reversal system of feeding, with that of the proteins of beef round, dried and defatted at a low temperature. Both test foods were incorporated in an otherwise complete diet in such amounts as to provide approximately 10 per cent. of protein (N × 6.25), of which nutrient the test foods

TABLE 1

THE UTILIZATION OF NITROGEN (PROTEIN) IN DEFATTED CORN GERM AND IN AUTOCLAVED SOYBEANS, IN COMPARISON WITH THAT OF THE NITROGEN OF BEEF ROUND

Rat No.	Utilization of corn germ nitrogen: Coefficients of true digestibility		Utilization of corn germ nitrogen: Biological value	
	Beef round	Defatted corn germ	Beef round	Defatted corn germ
229	100	87	77	84
231	100	84	77	78
233	100	82	74	83
235	100	87	72	80
237	99	79	73	66
230	100	90	77	80
232	100	77	86	79
234	99	87	79	79
236	99	89	77	72
238	100	88	77	75
Averages:	*99.7*	*85.0*	*76.9*	*77.6*

Rat No.	Utilization of soybean nitrogen: Coefficients of true digestibility		Utilization of soybean nitrogen: Biological value	
	Beef round	Autoclaved soybeans	Beef round	Autoclaved soybeans
239	100	85	77	73
241	100	83	70	66
243	99	86	75	73
245	98	81	72	70
247	99	86	71	70
240	100	84	76	66
242	98	83	77	67
244	99	84	75	60
246	100	87	77	68
248	100	85	72	62
Averages:	*99.3*	*84.4*	*74.2*	*67.5*

[1] G. R. Cowgill, *American Scientist*, 31: 142, 1943.

[2] Corn germ made by the wet-milling process, due to leaching with water and contact with sulfurous acid, may not be highly valuable, either as a source of protein or of vitamins.

[3] This estimate was made by Ezra Levin, president of the VioBin Corporation, of Monticello, Ill., in a private communication.

[4] H. H. Mitchell, *Jour. Biol. Chem.*, 58: 873, 1924.

[5] H. H. Mitchell and G. G. Carman, *Jour. Biol. Chem.*, 68: 183, 1926.

[6] Obtained from the VioBin Corporation of Monticello, Ill., through the courtesy of Ezra Levin.

furnished practically all. In the first period, 5 rats received the corn germ diet while their pair mates received, in equal amounts, the beef diet. In the second period, all rats received the 4 per cent. egg protein (standardizing) diet, and in the third period the two diets were fed as in period 1, but to opposite pair mates. The results for true digestibility (corrected for metabolic nitrogen in the feces) and biological value (percentage of absorbed nitrogen retained for maintenance and growth) of the nitrogen in the two foods are summarized in Table 1.

It is evident from these data that the protein (nitrogen) of defatted (solvent-extracted at low temperature) corn germ is 85 per cent. as digestible as the protein of beef round, but that its biological value for the growing rat is as high as that of beef round.

The average biological value of 78 obtained for this sample of corn germ may be compared with values of 50 to 65 obtained for the cereal grains, 51 to 60 for a series of nuts widely used in the American diet, 72 for the cashew nut, 94 for whole egg, 90 for raw whole milk, and 62 to 77 for various cuts of meat and edible animal organs.[7] These values were all obtained in this laboratory by comparable methods.

A comparison of the utilization of the protein of corn germ with that of the soybean, a comparatively newcomer in the American diet, was also undertaken. The soybeans tested were dried, defatted and autoclaved at 17 pounds steam pressure for 1½ hours. The data presented in the right half of the table were obtained by an identical experimental procedure with beef protein as a reference food. From these figures, it is evident that soybean protein is about as digestible as corn germ protein, but that the digested protein is appreciably less available in satisfying the protein requirements of maintenance and growth.

Thus, corn germ prepared by dry milling is available in considerable quantities as a protein supplement to the American diet. It is a food rich in protein and also in thiamine. When processed in such manner as to preserve its inherent nutritive properties, its protein is well digested, and after digestion it is as well utilized in satisfying the protein requirements of the body as is the protein of the best cuts of meat. In the difficult times ahead, with food shortage at hand or in immediate prospect, and a protein shortage a distinct possibility, a full utilization for human needs of the corn germ already available as a by-product of the corn milling industry would seem to be a wise eventuality. Furthermore, the withdrawal of corn germ from the corn milling by-products used as animal feeds would not precipitate a serious situation in livestock feeding because the protein thus withdrawn can be amply replaced from sources unfit for human consumption or less well utilized by the human, while the withdrawal of its thiamine is of no significance to animals living so largely on whole grains or forages.

[7] H. H. Mitchell, *Proc. Seventh Convention of the Royal Academy of Italy, Rome*, 1937, p. 101.

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CONTROL OF AIR-BORNE MICROORGANISMS BY ULTRAVIOLET FLOOR IRRADIATION

STUDIES of air-borne bacteria in living spaces have demonstrated that bacterial counts are correlated with human activity and that the highest number of bacterial colonies are recovered in the lower levels of such spaces. There are also reports that cross infections can be reduced to a measurable extent by prohibiting the making of beds immediately before dressings are to be changed and by carefully oiling floors and avoiding dry sweeping. It has long been known that pathogenic microorganisms can be recovered from the dust of rooms where carriers of such organisms are present.[1, 2, 3]

From these facts it may be inferred that bacteria of the air are closely associated with dust particles on floors and lint and dust attached to blankets, linens and clothes. During periods of human activity the momentary turbulence of the air raises dust which quickly subsides after the room is emptied or activity is reduced.

Because of these considerations it was thought that ultraviolet floor irradiation might be more effective in controlling air-borne bacteria than upper-air irradiation or that the two in conjunction might be more effective than the present practice of merely irradiating the upper third of rooms or wards.[4]

To check the effectiveness of ultraviolet floor irradiation several experiments were conducted in a sheet-metal-covered experimental chamber of 9×7×8 feet. The floor of this room was irradiated by 4 eight-watt low pressure mercury vapor glass lamps, 30 inches from the floor. All radiation from the lamps was reflected downwards. One half hour before each experiment a small amount of fine house dust was introduced into the experimental chamber. Two small fans were placed in opposite corners of the room. The fans were maintained at a constant speed throughout all tests.

Bacteria in the air were quantitated by the open

[1] E. White, *Lancet*, 1: 941, 1936.
[2] J. C. Thomas, *Lancet*, 1: 433, 1941.
[3] M. VanDenEnde and C. H. Andrewes, "Aerobiology," Am. Asn. Adv. Science, Misc. Publ. 17, 1942.
[4] W. F. Wells and M. W. Wells, "Aerobiology," Am. Asn. Adv. Science, Misc. Publ. 17, 1942.

plate method, the bubbler pump[5] and by the funnel device.[6] In each experiment four sets of samples were taken at 30-minute intervals. The effect of ultraviolet radiation was determined by starting the lamps after the second set of samples had been taken. As a control two sets of experiments were performed without lighting the lamps so as to estimate the effect of settling without radiation.

The results of these various runs are shown in Table 1. It will be observed that the ultraviolet floor irradiation produced a significant lowering of air-borne bacteria in the experimental chamber.[7]

The results are sufficiently striking to justify the suggestion that floor irradiation be combined with ceiling irradiation in practical tests in barracks or hospital wards to determine the effect, if any, of ultraviolet irradiation in lowering morbidity rates or preventing cross infection. If such experiments be attempted it must be borne in mind that certain types of flooring may prove to be capable of reflecting sufficient amounts of ultraviolet to cause harmful effects.

TABLE 1

THE EFFECT OF ULTRAVIOLET FLOOR IRRADIATION WITH FOUR ULTRAVIOLET LAMPS ON AIR-BORNE BACTERIA. LIGHTS ON 10 TO 20 MINUTES AFTER THE SECOND RUN. TIME BETWEEN RUNS ABOUT 30 MINUTES. TEMPERATURE: 31–35° C. RELATIVE HUMIDITY: 53–63 PER CENT. ADDITIONAL FIVE EXPERIMENTS WITH LIGHTS ON AND OFF AND ONE ADDITIONAL CONTROL GAVE SIMILAR RESULTS TO THE ABOVE EXPERIMENTS

		Experiment 1					Control					
		Run	No. of observ.	Mean per plate	σ	No/10 c. ft.		Run	No. of observ.	Mean per plate	σ	No/10 c. ft.
Open plate	Lights off	1	10	20.3	2.04	...	Lights off	1	10	20.8	5.40	...
		2	10	21.1	1.83	...		2	10	17.5	4.45	...
	Lights on	1	10	4.5	1.25	...		3	10	20.5	8.20	...
		2	10	5.4	2.04	...		4	10	23.2	2.85	...
Bubbler pump	Lights off	1	12	4.8	.73	242	Lights off	1	12	4.5	1.32	225
		2	12	4.2	.74	210		2	12	4.3	.96	217
	Lights on	1	12	1.3	.38	63		3	12	3.3	.70	169
		2	12	1.9	.44	96		4	12	4.1	1.19	204
Funnel device	Lights off	1	2	49	...	49	Lights off	1	2	59	...	59
		2	2	43	...	43		2	2	50	...	50
	Lights on	1	2	29	...	29		3	2	47	...	47
		2	2	16	...	16		4	2	46	...	46

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

SPECTROSCOPIC MICRODETERMINATION OF MUSCLE ADENYLIC ACID

THE absorption spectrum of adenylic acid in the ultraviolet shows a maximum at 2,600 Å, which is characteristic for the adenine group.[1] The deaminated product inosinic acid has its absorption maximum at 2,500 Å. This difference in absorption spectra between the amino and the hydroxy purine nucleotides was described as early as 1932 by Myrbäck, Euler and Hellström[2] and recently a corresponding difference in absorption spectra has been described for adenine and hypoxanthine.[3] Adenylic acid has a much higher absorption than inosinic acid in the range: 2,700–2,600 Å. At 2,650 the absorption of inosinic acid is only 40 per cent. of that of adenylic acid (see Fig. 1). This great difference in absorption spectra has been used in the present studies as a basis for a very sensitive and specific test for Schmidt's deaminase[4] or for identification and quantitative de-

[5] S. M. Wheeler, G. E. Foley and T. Duckett Jones, SCIENCE, 94: 445, 1941.

[6] Alexander Hollaender and J. M. Dalla Valle, *U. S. Public Health Reports*, 54: 574, 1939.

[7] A difference of three times the σ of the series between bacterial counts with lights on and off was considered as a criterion of significance.

[1] Ch. Dhere, *C. R. Soc. Biol., Paris*, 60: 34, 1906.

* The opinions advanced in this paper are those of the writers and do not represent the official views of the Navy Department.

[2] K. Myrbäck, H. Euler and H. Hellström, *Zs. physiol. Chem.*, 245: 65, 1932.

[3] M. M. Stimson and M. A. Renter, *Jour. Am. Chem. Soc.*, 65: 153, 1943.

[4] G. Schmidt, *Zs. physiol. Chem.*, 179: 243, 1928.

termination of muscle adenylic acid (adenosine-5-phosphate). If a few micrograms of Schmidt's deaminase are added to a solution of adenylic acid and the absorption at 2,650 Å is determined in the Beckmann spectrophotometer one observes a steady decrease in absorption, proportional to time within the first few minutes, decreasing in rate later. The absorption decreases to less than half (45 per cent.) of the original but seems to come to a standstill before complete deamination has been reached. It has not so far been possible to observe any amination of inosinic acid with ammonia salts.

The deaminase test is performed in the following way. To 10 or 15 μg adenylic acid per ml (5×10^{-5} M) containing 0.05 M succinate buffer pH 5.9 is added to 2 to 5 μg of Schmidt's deaminase, purified through isoelectric precipitation and ammonium sulphate fractionation. The deamination takes place in a quartz vessel, 1 cm in depth, which is exposed to ultraviolet light of the wavelength 2,650 Å. The deamination causes a fall in the absorption and the decrease is read every minute on the absorption scale of the Beckmann spectrophotometer. A measurement of the absorption in the range from 2,400 to 2,800 Å before and after addition of deaminase shows the spectra of adenylic acid and inosinic acid (with traces of adenylic acid) respectively (Fig. 1). A decrease in absorption

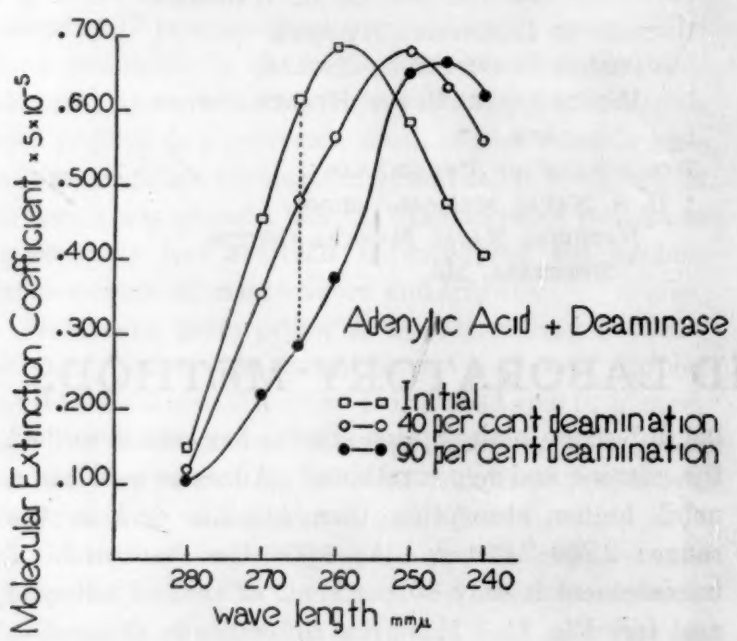

FIG. 1.

at 2,650 Å corresponding to less than 10 per cent. of complete reaction is readily detectable. If the adenylic acid concentration is $5 \times^{-5}$ M, a 10 per cent. decrease corresponds to a liberation of 0.07 μg N.

The formation of adenylic acid when myokinase[5,6] is added to adenosine diphosphate (2 adenosine diphosphate ⇄ adenosine triphosphate + adenylic acid) can be also demonstrated in the micro test. Addition of purified deaminase to a 5×10^{-5} M solution of adenosine diphosphate (pH 6.2) does not give rise to any change in the absorption at 2,650 Å. If now a few micrograms of myokinase are added the absorption decreases proportionally with the amount of added myokinase, provided deaminase is in excess. Between 40 and 45 per cent. of the adenosine diphosphate is converted to inosinic acid, indicating that more than 80 per cent. of the adenosine diphosphate has been converted into the tri- and monophospho-nucleosides.

The spectrophotometric myokinase test requires one to two μg pyrophosphate P (as adenosine diphosphate) where the hexokinase test requires 20 to 50 μg pyrophosphate P. On the other hand, in the spectrophotometric test both the deaminase and the myokinase act outside their pH optima. The deaminase has a sharp pH optimum at 5.9[4] the myokinase a broad optimum between pH 7 and 7.5[6] and neither of the enzymes has any appreciable activity at the pH optimum of the other. At pH 6.2–6.5 both enzymes exhibit a fairly high although not optimal activity.

The deaminase preparations show a slight effect on adenosine. However, adenosine is deaminated 60 times slower than adenylic acid.

Adenylic acid from yeast nucleic acid is not deaminated by the deaminase (*cf.* footnote 4), a fact which in 1928 led Embden and Schmidt[7] to the differentiation between muscle adenylic acid (adenosine-5-monophosphate) and nucleic acid adenylic acid (adenosine-3-monophosphate).

Thus, the method is specific for muscle adenylic acid (and diadenylic acid[8]). Methods based on adenylic acid as a phosphate transfer system[9] are specific for adenosine-5-phosphate derivatives but can not distinguish between adenylic and adenosine diphosphate. The micromethod presented here does distinguish between adenylic acid and adenosine diphosphate due to a separation of the deaminase from myokinase.[6]

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